Confederation of Indian Industry

# STRIDE®

Science • Technology • Research • IP • Design • Entrepreneurship

## Journal of Technology Leadership and Innovation

December 2021, Volume 1, Issue 1


From India to the World

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# Preface

CII is launching its National Journal of Technology Leadership and Innovation. The Journal is named as 'STRIDE', which also abbreviates for the core themes and focus areas of the journal - Science, Technology, Research, IP, Design & Entrepreneurship. The Journal is a multidisciplinary, peer-reviewed, special expertise periodical. It broadcasts and presents 'unique, original & impactful' technologies and innovation accomplished by industry, researchers, academia and the Indian science and technology ecosystem at large.

With technology playing an integral role in India's big leap towards AatmaNirbhar Bharat, the Confederation of Indian Industry (CII) is strategizing for a new orbit in shaping technology for India's growth trajectory. Indeed, CII has defined its theme for 2021-22 as 'Building India for a New World: Competitiveness, Growth, Sustainability, Technology.' This Journal explores the opportunities and scope of technology, design and innovation ecosystem of India in particular. It highlights and reinforces unique strengths of Indian industry and research institutions, and features the development in latest technology frontiers which are going to influence and shape up the future of India (& world) in the coming decade.

The papers featured in the journal will have technology leadership perspective oriented with key focus on innovation, design, IP and techno-commercial applications. The Journal will also feature successful innovation case studies from industry, and a section on worked-upon-innovation ideas. The innovation ideas presented are planned to be the blue-prints of innovative (not necessarily unique in every case) which can be picked up for incubation and development by any research lab or tech-centre across the nation. In doing so, and in the process of publishing blueprints of these untested-innovation ideas, the journal is also envisaged to become a national repository of innovative ideas, while enabling collaborations.

We would like to thank our patrons from the Dept. of Science & Technology, Office of Principal Scientific Advisor to the GoI, and the Dept. for Promotion of Industry and Internal Trade, leading industry leaders, eminent scientists and academicians, and international agencies with whom we had a series of interactions to converge on the expectations and eventual features of this journal. We look forward to having further views and feedback to help us in improvising and continuously evolving the journal and its impact.

# Foreword

**Mr. T V Narendran**
President, CII
CEO & Managing Director
Tata Steel Limited

As India stabilizes after the deep ravages of the Covid-19 pandemic on the world economy, the imperative ahead for the country is to maintain a high pace of growth over the next few years. Indian Industry has shown its mettle in adapting and reconfiguring in a severe crisis situation and supporting the country. A competitive and sustainable industry must now assume a lead role in India's future development and play a key role in the emerging shape of the global economy.

Given this, the Confederation of Indian Industry (CII) has defined its Theme for 2021-22 as 'Building India for a New World: Competitiveness, Growth, Sustainability, Technology.'

The fourth pillar of the theme, Technology, even more than trade, is now at the core of geopolitical dynamics. The future promises to be dominated by greater knowledge intensity and more applications of digital technologies. Countries will compete on proprietary knowledge and technologies and we need to work with both the Government and industry members to ensure that as a nation and as industry we accelerate into the future.

New India has a strong focus on science and technology, and the current crisis has reinforced this further. Indian technology, design and innovation ecosystem is strengthened through reforms in intellectual property protection. India is among the top-ranking countries in the field of basic research and stands third in the number of science and engineering publications in the world. The pandemic has accelerated the pace of digital adoption like never before, with new technologies such as Artificial Intelligence, robotics, machine learning, and others gaining space. Going forward, disruptions in newer technologies will be the pivotal differentiator. Indian industry must keep pace with these changes and be a leader in shaping new and emerging technologies.

Leading up to India@75 and for the journey ahead, we must strive to design a morally, economically and technologically advanced country, in partnership with the Government, industry and all key stakeholders. India's unparalleled demographic fabric would enable us to thrive in an era of disruptive technologies.

# Message

**Mr Chandrajit Banerjee**
Director General
Confederation of Indian Industry (CII)

Science and technology are the bedrocks of a knowledge economy. India's aspiration of becoming a USD 5-trillion economy in the next few years is intricately entwined with its potential to lead the innovation, design and IP arena, with global technology standards originating from Indian industry.

Over the past two decades, CII has been at the helm of nurturing an ecosystem for technology adoption and industrial innovation. As India marches towards its 75th year of Independence in 2022, CII pledges to provide a roadmap for rapid acceleration in technology adoption and help navigate a highly volatile, hyper-globalized economic environment. Emphasis on fostering a culture of collaboration among industry and academia in research, innovation and technology applications is fundamental for opening new vistas for the post-pandemic economy.

CII initiated its activities in the area of technology during the late-1990s under the chairmanship of late Dr APJ Abdul Kalam, focusing on guiding Indian industry's initiatives in innovation and R&D. Today, technology leadership is one of the thrust areas of CII and the Indian growth story bears testament to CII's work in specialized areas, including Design, Innovation, Sustainability, Intellectual Property Rights, Digital Transformation, etc. In 2007, CII established the Global Innovation & Technology Alliance (GITA) for promotion and management of international industrial R&D programs on behalf of the Government of India.

The emphasis on enterprise development via technology intervention is evident in CII's training and capacity building programs, that are implemented throughout the ranks of Indian industry, cutting across various sectors. CII pioneered the Global Innovation Index, Industrial Innovation Awards, Design Excellence Awards, Executive Design Thinking Program, Intellectual Property Facilitation Center, and others to build competitiveness and democratize design and innovation for Indian businesses.

Any focus on the consolidation and advancement of Indian knowledge ecosystem must consider all key stakeholders and develop a common platform for knowledge transfer. The CII STRIDE Journal of Technology Leadership and Innovation promises to be the platform that examines and explores the scope of technology, design and innovation ecosystem and its impact on our country and the world at large. I look forward to the ensuing conversations.

# Editor-in-Chief



# Editorial Board









# Table of Contents

# CEO SPEAK

# A Conversation with

**Mr Vipin Sondhi**, Chairman, CII National Committee on Technology, R&D and Innovation, and MD & CEO, Ashok Leyland Ltd.

### In your opinion, how important is it to leverage the partnership between industry and academia in advancing the science, technology and innovation ecosystem of a nation. In your view, how can India improve and increase the engagements between its industry and academia?

Collaboration between industry and academia is key to driving R&D, innovation and growth in science and technology. These elements are, undoubtedly, the most important wealth for a country.

India's Gross Expenditure in R&D (GERD), is 0.62% (Word Economic Forum 2019-20) of its gross domestic product (GDP), significantly lower than the 1.5% - 3% of GDP spent by the top 10 economies.

In most large developed and emerging economies, the participation of business enterprises and academia in GERD is high, which increases the likelihood of sophisticated product innovation.

Industry-academia collaborations create an environment for next-gen start-ups to thrive, provides a platform for open collaboration, enables pragmatic innovations serve business needs and generate workforce who are ready for the industry.

In India, there is still lack of optimum co-operation arising due to stakeholders working in silos. Still, a lot more needs to be done to improve the collaboration between industry and academia.

We must work towards increasing the reach to several other institutes and industries of all sizes

We must align academic research to Industry requirements as much as possible. In order to address the current and future Science, Technology and Innovation challenges in India, the development and deployment of sustainable and indigenous technologies is a must.

We need to build and contextualize models for industry-academia linkages in India, based on empirical evidence from successful industry-academia models, nationally and internationally.

### What are the expectations from industry which will invigorate the industry-academia collaborations?

Industries are better placed to take the lead in forging a strong collaboration by encouraging participation from academia. The start-ups of today are setting up laboratories and incubation centers at universities to bridge the gap and evince participation from academia. This effort must intensify as we move forward.

**Industry can lead the way to make the collaboration work by:**

- Helping design the curriculum that would involve an extensive internship, where the students work on live business problems
- Spelling out a problem and articulating its strategic importance
- Putting together a team that have technical skillset, networking skills and business awareness
- Clearly laying down the vision and deliverables in conjunction with academia
- Staying invested with a university and cultivating relationships
- Facilitating the team from academia to have interactions with various functions for a 360-degree view

Any partnership works on the principle of collaboration and contribution by both entities.

**It is generally observed that while academia focusses on Technology Readiness Levels of 3-4, only higher TRLs of 7-9 excites and private sector. This 'Valley of Death' between TRL 4 and TRL 7, where neither academia nor the private sector prioritise investment is a challenge. Consequently, many technologies, albeit promising, finish their maturity journey prior to deployment. In your opinion, what collaborative efforts are warranted to bridge this Valley of Death?**

Academia are limited by technical factors in their research while industry is compelled in their choices and flexibility by a series of external factors including regulations and customer expectations.

While there is a consensus that academia must perform curiosity-driven research to find innovative solutions, there is a need to aim for commercialization of the development. The act of preparing research for commercialization requires commercial skills in addition to making it production ready.

There have been many successful models conceptualized and in use in emerging economies to bridge this Valley of Death. One such models, that has been successful, is the innovation intermediary model established in Germany called the Fraunhofer Society Model. This model focuses on bridging the gap between TRL 4 and TRL 7.

The Fraunhofer Society model provides a unique resource that addresses this problem by developing the innovation into a functional technology that can be validated and demonstrated, in effect de-risking it. The funding required for research increases as the cycle progresses while the risk of technological failure keeps decreasing concurrently.

In India, a third party in the form of a start-up adopting the Fraunhofer Society model, could be the answer to bridging the Valley of Death.

**Industry has always shown its willingness to engage directly with the National Innovation missions of the Govt. of India. Industry has both the capacity and capability of executing these national missions. However, the established academia institutions continue to remain preferred partners of Govt. when it comes to allocate grants for the national missions. How do we integrate and leverage the immense capacity/capability of industry with these national missions, and where do you think Industry need to further work and step up its engagement with the Govt. on these missions?**

National Missions of the GoI are critical to the growth and development of our Nation. There exists an excellent opportunity for engagement between the Industry and Government right from the conceptualization stage.

- Industries can contribute in the development of Framework and Vision
- Government gets access to new thinking
- Networking capabilities of the industry can be of great help
- Industry brings in latest technology, innovation and improved efficiencies
- Sharper estimation & efficient project management can help keep costs down
- Government will have access to professionals with requisite skill sets

To conclude, GoI can highly benefit from expertise that Industry can offer and overcome the limitation of resources through active engagement and collaboration.

**As India ushers in the era of new and emerging technologies, it becomes inevitable for the young tech savvy population to apply their learnings for solving major critical challenges. What is your advice to this young generation? How can they contribute towards improving these collaborations?**

The exponential spread of technology, over the last few decades, has been transforming human lives. This change is being driven by the younger generation, the millennials and the Gen-Zs. They display a mastery in using technology for daily as well as diverse purposes. The younger generation are better equipped to use the information available to them productively.

They want a flexible approach to work, but seek regular feedback and encouragement. They want to feel their work is worthwhile and that their efforts are being recognized. They aspire for careers that truly have a positive impact on the society.

While the aspirations of the generation are justified and it is important that their needs are acknowledged and met, the younger generation must realize that they need to harness their energies and deliver greater outcomes to build Brand India. To become globally competitive, the young need to apply their learnings to build products and solutions that are commercially viable with utmost focus on quality and reliability. They must work towards raising the credibility of Indian innovations and lead India to be among the best in the world.

Section 1

# KNOWLEDGE PAPERS

CII STRIDE

December 2021, Volume 1, Issue 1

# Science, Technology and Innovation-driven Enterprise

## India's Opportunity for Global Leadership

**Mudit Narain**, Technology Officer, Office of the Principal Scientific Adviser, Government of India

**K VijayRaghavan**, Principal Scientific Adviser, Government of India

The scientific, technological and innovation (STI) prowess of any country is instrumental in shaping and sustaining its industrial sectors, delivering economic growth, jobs, wealth creation and ensuring a strategic edge. The unprecedented increase in the speed of scientific and technical innovation in the past couple of decades has transformed the fabric of daily life, impacting the course of economic and social development. Technology-driven, and innovation-focused enterprises that form the bedrock of STI-based entrepreneurship have moved from being a buzzword to a critical component of national economic and strategic power.

Government initiatives such as the Biotechnology Industry Research Assistance Council (BIRAC), New Millennium Indian Technology Leadership Initiative (NMITLI), Technology Development Board (TDB) and more recently Innovations for Defence Excellence (iDEX) seek to catalyze innovation-centered scientific and technological developments by synergizing the competencies of publicly-funded R&D institutions, academia, startups and the corporate sector. Built on such foundational programs, **India's current innovation and entrepreneurial ecosystem is now shifting from efficiency-seeking e-commerce marketplaces to deep-tech and IP-driven innovative enterprises creating new products.** There are now multiple success stories within India of young entrepreneurs identifying technologies and converting them into user-friendly products and services. While a plethora of challenges remain, young entrepreneurs are establishing the system of converting STI investments to consumer convenience and economic growth, through entrepreneurship.

In the face of a massive pandemic and the threat of unparalleled economic collapse, countries around the world embarked on a variety of measures to protect citizens - wielding novel financial, industrial, and regulatory instruments, and steering markets to develop digital technologies and pharmaceutical interventions in record time. Amidst such unexpected circumstances, the Indian S&T enterprise stood firm and aligned its efforts to address collective challenges. India developed indigenous technologies and tools to battle the pandemic and its associated problems, such as diagnostic kits, reagents, PPE kits, drug repurposing and above all, an indigenous vaccine - results of the numerous industry-academia-government partnerships that were built quicker than ever before.

India has been a destination for low-cost, outsourced services since the late 1980s. This boosted employment and fuelled urbanization, eventually creating a trained workforce, well versed in providing nimble solutions to complex problems. In the last few years, India has leapfrogged many stages of technological development and has taken an exponential path from barely any connectivity to being the second most connected nation in the world. This technology penetration and connectivity coupled with the trained workforce empowers India to now reassert its position as a global leader in STI endeavours, and not merely a supplier of skilled technical manpower. A country's innovation ecosystem relies heavily on knowledge exchange between academia and the commercial sector. Effective synergy between these stakeholders is key in transforming research to usable products. However, the transfer of knowledge embedded in public research organizations to tangible technology does not happen spontaneously. Acknowledging this gap and identifying systems to bridge it is critical for building an AtmaNirbhar Bharat of the future. Multiple new pathways of collaboration between industry and academia are being developed such as academia -startup co-creation, acqui-hiring by corporates, open innovation platforms, and others. There are islands of excellence such as those at IIT Madras, which thrives and excels through strong industry linkages, based on a unique 'Credit System' for sustaining these engagements. IISc Bangalore has instituted Society of Innovation and Development (SID) that acts as the Institute's scientific repository and carries out engagements with industry. IIT Delhi's innovation ecosystem has started to yield multiple employment-generating unicorn startups, as well as deep tech innovations. IIT Bombay's SINE is a source of globally-competitive STI-based startups. The Centre for Cellular And Molecular Platforms (C-CAMP) at the National Centre for Biological Sciences, Bengaluru, has created an entire ecosystem around biotech, including incubation, seed and equity funding, to spur innovation in the sector. While many such institutions and their incubators have made efforts to reach out to Indian corporates, it is now incumbent on the latter to make deeper efforts to collaborate with startups, Indian public R&D system, and innovators to bring new technologies as products to the marketplace.

For India to create a critical mass of globally competitive enterprises with high-density knowledge capabilities, accessing global talent will be as important as harnessing local capabilities. India Inc should be able to sustain a network of research centers in specialized technological areas in different countries; develop a vibrant platform for learning, exchange of ideas and enable experimentation globally. This engagement with the global S&T world is imperative and inevitable for talent gathering and cutting-edge research and transformation for India as a whole.

As we reorient in context of the global challenges like post-pandemic recovery, the transition to industry 4.0, and global climate change, India is at a crucial juncture to foster a robust ecosystem of partners that develop and deploy affordable technologies. **It is time for academia, startups and the corporate sector to collaborate to bring India to the front of this rapidly-evolving revolution in innovation-driven entrepreneurship.** The Government will be an enthusiastic partner and provide all the support needed in this effort to bring India to the global fore of deploying science in the service of citizens and improving the industry's competitiveness.

CII STRIDE

December 2021, Volume 1, Issue 1

# Assured Success through ASSURED Innovation Framework

**R A Mashelkar**, FRS, National Research Professor

## Introduction

Innovation is a translation of a new idea into practice. Any innovation is considered as successful, when it is done with speed, it reaches scale, and it remains sustainably profitable and impactful over a long period of time.

The journey from mind to marketplace is an arduous process. But after entering marketplace, to remain successful in business over a long period is also challenging.

First consider the success rate of any idea getting converted into business. An interesting analysis has been done by Stephen and Burley for Industrial Research Institute. It lists out the significant odds that face the would-be innovators by analysing consistent data from new product development, potential activity and venture capital experience.

They show that there is a universal curve, which illustrates the number of substantial new product ideas surviving between each stage of the new product development process. It shows that out of 3000 raw ideas (handwritten), 300 are submitted, which lead to around 125 small projects, further leading to 9 significant developments, 4 major developments, 1.7 launches and 1 success.

India has the third largest startup ecosystem in the world. A 2017 study titled 'Entrepreneurial India', by the IBM Institute for Business Value and Oxford Economics highlighted that 90% of Indian start-ups fail within the first five years. This is despite the fact that several of these startups had novel ideas, some were receiving big investments, some were backed by leading global investors, yet they failed and were forced to shut down. Lack of innovation is often cited as the most common reason for their failure.

But how long will the 10%, who enter the marketplace finally remain successful? A study by McKinsey shows that the average life span of companies listed in Standard & Poor's 500 was 61 years in 1958. Today, it is less than 18 years. Only 10.4% of the Fortune 500 companies in 1955 have remained on the list during the 64 years since in 2019.

I propose in this paper a new framework, which, if used proactively, can potentially increase, first, the chance of converting an idea into a business, and then remaining a successful business for a prolonged period.

## ASSURED Innovation Framework

Ravi Pandit and I wrote a book, 'From Leapfrogging to Pole-vaulting: Creating the Magic of Radical yet Sustainable Transformation' in 2019, which won the Tata Literature Live! Business Book Award in the same year.

In the book, we emphasised the shift from reactive leapfrogging to proactive pole-vaulting through radical and sustainable transformation of an enterprise. In order to assure success, we proposed using the ASSURED Innovation framework.

ASSURED comprises seven important attributes, namely, being affordable, scalable, sustainable, universal , rapid , excellent and distinctive.

### Affordable

An affordable solution creates access for everyone across the economic pyramid. Affordability is achieved by implementing extremely efficient operation, production and distribution systems. Cost of customer acquisition has to be low. Lowest cost of fixed and operating are as important as business model innovations such as 'pay per use', or workflow, or system delivery innovations.

### Scalable

Scaling the solution to largest number of addressable beneficiaries makes the largest impact. In depth understanding of the market addressability is as important as identification of Blue Ocean ( unexplored and vast marketplace for the offering with the entry barriers).

### Sustainable

The solutions have to be environmentally sustainable, economically feasible (with robust business and revenue models), socially acceptable and also adaptable to sudden or radical policy changes. Proactive planning for obsolescence of skills, capabilities and processes by being agile and nimble is important. Good governance is essential for sustainability. PESTEL analysis, which Focuses on political, economic, social, technological factors and also includes additional assessment of the environmental and legal factors that can impact the business is fundamentally important.

### Universal

Universal means user-friendly, simple and maintenance free products and services. Standardisation of design, supplies, inputs, processes, customer needs, quality of supplies and resources contribute towards universality . All the principles of universal design such as flexibility, simplicity, minimal inconvenience, tolerance for error and equitable use are as important as is smart design thinking.

### Rapid

The journey from mind to marketplace has to be rapid, and so is the fast adaptability to changing market conditions after entry into market. This speed to market, speed of competitive response to a competitor, decision making speed, flexible organisational processes that impact decision-making speed, all these are important.

### Excellent

The endeavour has to be to use the state of the art technological or novel non-technological solutions. But that is not enough. We need business excellence, which is about developing and strengthening the management systems for achieving excellence in everything that an organisation does, including leadership, strategy, customer focus, information management, people and processes.

### Distinctive

Innovation and not imitation is the key. There is no use creating 'me too' products and services. Solutions must be protected by robust intellectual property portfolio. Raising entry barriers for the competitors, primarily through creative self-destruction , distinctive brand creation, clear differentiation, creating products with low replicability are the keys to success.

Three important points about the factors in the ASSURED framework. First, all the seven factors are dependent on each other. Better affordability can lead to bigger scalability. Second, the factors are time variant. For instance, failing to change with changing environmental regulations can affect sustainability. Third, either fully quantitative, semi quantitative or qualitative value can be attached to all the seven factors. Weightage given to each factor depends upon the type of business.

Finally, what we require is not just technology innovation, but 'total' innovation. Total innovation must include technology innovation, business model innovation, workflow innovation, system delivery innovation, process innovation, organisational innovation and policy innovation. In fact it is the innovative combination of these that create scalable and sustainable businesses.

## Failure assured if ASSURED test fails

'Failure is the best teacher' is not just a maxim. To understand the efficacy of the ASSURED model, we have selected a few innovations that shook the imagination of the world. Each of the current successes, from Apple to Amazon, from Facebook to Google, from Samsung to Toyota, satisfies the requirements of the ASSURED framework and at all times in their journey. The common features among failures are common too—failure is assured in the long run if the innovation fails the ASSURED test at any point along its journey. Here are some telling examples.

Napster had 80 million users. It doesn't exist today. It failed the S test of Sustainability from a societal perspective. Music creators did not want Napster to break IP laws that were long respected by society. iTunes, with its vast catalogue of $1 songs, is often referred to as a more evolved and successful version of what Napster aimed for but could not achieve.

BlackBerry had 50 million customers in year 2001. It doesn't exist today. BlackBerry devices were top of the class and had successfully hooked email-obsessed Wall Streeters and other corporate users. They pioneered 'push email', and the QWERTY keyboard on their devices made it easier for users to fire off emails and instant messages. It failed to anticipate the smartphone revolution that was led by consumers and not business customers.

Blackberry had once met all the criteria in the ASSURED framework. They failed later because they did not offer customers better experience or user-friendliness, which their competitors provided. U and R from the ASSURED framework went sorely missing in the later stages of BlackBerry's products.

Kodak ruled the world for decades but had to file for chapter 11 bankruptcy in USA. It did not remain 'distinctive' and 'user-friendly', when the digital camera arrived. The same was the case with Polaroid, the leaders in instant photography.

Borders was leading international book retailer. Doesn't exist today. It failed to adapt to the digital and online books age, ignored consumer preferences, and was soon failed the D and U test by not remaining 'distinctive' and 'user-friendly'.

Israeli EV startup, Better Place was posed as rival to Tesla at one point but failed due to non-viable business model, the S factor.

After 70 years of being in the business, Atlas Cycles was shut down. At the time of business failure Atlas Cycles failed to meet most of the ASSURED parameters.

ZebPay, India's largest cryptocurrency trading platform in India had to shut down due to regulatory non-compliance, the S factor.

These were all companies who had achieved great 'performance', and they failed the ASSURED test.

Let us look at a case, where a great 'promise' was not fulfilled because ASSURED test could not be met.

Tata Nano was conceived as People's car. It was **Affordable**, the price at its launch announcement being Rs.1 lakh. It was **Excellent** in terms of technology, since over 70 patents covered its remarkable innovations. It was **Distinctive** in many ways.

However, its marketing went awry. Tata Nano represented 'affordable excellence', but while marketing, excellence was put at the back end and affordability was put at the front-end, which automatically translated into Nano being a cheap product, and the aspirational young generation did not want a cheap car. So, the **U** part failed. The **R** part came into difficulty because production of Nano had to move from Singur to Sanand, losing two years. And obviously then scale and sustainability could not be achieved.

In all these cases the sustained success was not assured, because somewhere along the line, the ASSURED test failed.

## Contemporary Indian ASSURED Innovation Cases

We give here three illustrative contemporary Indian examples, first is a growing startup, second is a startup turned into a successful company, and the third is  a new technology led new company that became successful rapidly and massively.

## Dozee By Turtle Shell Technologies: A Growing Startup

It is estimated that India has only 2 million hospital beds and 0.12 million ICU beds. What's worse, most of the ICU beds are concentrated in the private sector, with substantial variation in available resources across states. While this presented a healthcare problem even before the Covid-19 pandemic, it has become even more critical in 2020.

The lack of ICU beds was a major concern even before the pandemic. Anjani Mashelkar Inclusive Innovation Award (AMIIA) winner for 2020 – Dozee has the potential to partly address this bleak situation.

Dozee is a is continuous, contact-free vitals monitor with remote monitoring capabilities and alert system that converts any bed into a step-down ICU in less than 2 minutes.

In COVID times, 5000 beds were enabled with health monitoring, helping patients across India in 220 hospitals so far.

**Let's view it in the ASSURED framework.**

A: It is Priced at Rs 100 per day, which is about 1/10th of the cost of conventional alternatives.

S: 75000 patients have been monitored so far in just a span of few months.

S: Aims to install 50,000 ICU beds across India in the next 6 months and reach one million in the next 3 years. Currently 1400 out of 5000 beds have been supported by CSR funds so far. The demand in public hospitals is large but the slow purchase procedures there are slowing down the scale up.

U: User has to simply put device under the mattress. Vital parameters are collected automatically. Setting up Dozee requires minimal technical expertise and it can be used in home settings.

R: Can convert any bed into step-down ICU in just 2 minutes

E: Uses sophisticated Ballistocardiograph technology. Medical-grade accuracy of 98.4% contact-free vitals monitor with remote monitoring capabilities. The device also lets clinicians set thresholds to trigger alerts for body vitals. Incorporated AI technology brings in predictive capability.

D: Contact-free vitals monitor with remote monitoring capabilities. Dozee monitors critical parameters so reliably that one nurse can handle 100 patients, ten folds more than the normal.

## ZERODHA – India's largest retail online brokerages: Start-up turned company

Zerodha is a financial service company offering stocks trading, mutual funds, and bonds. In just 10 years, Zerodha leads the industry by a wide margin with over 6 million customers, of which 3.7 million were on-boarded in FY21 alone. Zerodha' s disruptive pricing models and in-house technology have helped it in becoming biggest stockbroker in India in terms of active retail clients. It contributes to over 15% of all Indian retail trading volumes. It became a unicorn last year.

**Let's view it within the ASSURED framework.**

A: Lowest commission, and the firm's ability to outperform competitors on price because of low operating costs.

S: Completely Digital offerings so easy to scale but facing competition from new entrants which have deep pockets.

S: 3.7 million were on-boarded in FY21 alone.

U: Platform is simple to use for new users.

R: The platform seamlessly handled 100 % growth in concurrent users during Covid-19.

E: It's trading and investment platform, Kite, is a minimalistic application that serves the needs of diverse users.

D: Zerodha's 'zero brokerage' structure disrupted traditional brokers. Charges 20 Rs flat fee per transaction for Intra-day and F&O.

## Jio: A Successful Enterprise

Jio was launched in 2016 and it has become world's 2nd largest mobile data carrier in less than 5 years. Today about 425 million Indians enjoy the benefits of free voice calling and extremely affordable high speed 4G internet using their 4G LTE technology. Last year, Jio platform raised $ 15 Billion (INR 1.15 Lakh Cr) from leading global investors in just two months, while in 2019 the entire Indian startup ecosystem raised $12.7 Billion.

**Let us view Jio in the ASSURED framework**

A: Jio offers free voice calling for life. Jio also did away with national 'roaming charges', marking the first time in India's history that the length and breadth of the nation are truly connected.

S: World's largest all-IP network. Acquired 100 million subscribers in just 170 days. Currently about 400 million subscribers

S: Jio's network is uniquely positioned to quickly and seamlessly upgrade from 4G to 5G. Recently, Jio has received the necessary regulatory approvals as well as trial spectrum for initiating 5G field-trials. The entire 5G Standalone Network has been installed in Jio data centres across the nation.To develop the end-to-end 5G ecosystem, Jio is now working with leading global partners to develop a full range of 5G-capable devices. The Jio 5G technology is well positioned to create compelling applications for consumers and enterprises spanning Healthcare, Education, Entertainment, Retail and other key verticals of the economy

U: Simple, customer friendly plans – pay for one service. Ecosystem of entertainment, payment and other services

R: Jio become number one player in India in less than 5 years deployed through technological, product and business model innovations. Other equally important infrastructure development included 250,000 route kilometres of fibre optic cables laid, done using high-tech machines that laid the fibre deep underground with minimal surface disturbance just by drilling two holes.

E: One of the most important innovations at Jio was its configuration- Jio's greenfield LTE network is the first countrywide deployment of VoLTE or voice over LTE in India. It provides 15-20 MBPS speed that enables high definition voice calls. Jio deployed microcells technology for enhancing connectivity.

D: Fast-tracked Aadhaar-based eKYC (Know Your Customer) which allowed SIM activation in 5 minutes instead of a few days

## ASSURED Use Cases in Innovation Ecosystem

"ASSURED Total Innovation" model has been successfully implemented by various government agencies and private entities in India. Central Government's Department of Drinking Water and Sanitation adopted it for evaluation of innovations in the drinking water sector. Ministry of skill development used it for National Entrepreneurship Awards (NEA). National laboratories in CSIR are using it for selecting, monitoring and funding projects research projects.

JSW and The Times of India jointly leveraged it for Earth Care Awards (ECAs). Marico Innovation Foundation (MIF) used the framework for the MIF awards.

| | Stakeholder Use Cases |
|---|---|
| **Research Institutes** | • Technology evaluation<br>• Technology/innovation benchmarking<br>• Decision support matrix for projects funding |
| **Startups** | • SWOT Analysis<br>• Identifying probability of success<br>• Formulating winning strategy |
| **SMEs** | • Identifying roadblocks for scaling up<br>• Formulating winning strategy |
| **Corporates** | • Identifying hot startups<br>• Innovation/tech scouting<br>• Innovation portfolio management<br>• Diagnostic tool for identifying commercialisation barriers |
| **Investors (Angel/ VCs)** | • Promising startups for investment<br>• Portfolio management<br>• Decision support matrix for funding decision |
| **Innovation Accelerators** | • Funding decision tool<br>• Identifying gaps in successful commercialisation |
| **Government / Development Agencies** | • Recognizing award worthy companies<br>• Best practices identification |
| **Industry Association / Foundations** | • Innovation benchmarking<br>• Best practices identification |
| **Policy Makers / Think Tanks** | • Public procurement policy |

As regards the startups, the framework is being incorporated by Maharashtra State Innovation Society for selecting startup week awardees. Venture Centre in Pune, which won the inaugural best incubator award at the hands of the President of India is using it for evaluating and monitoring some of the incubators. JioGenNext, a leading corporate accelerator is using it for selecting startups.

In the corporate world some companies, including TCS in India and Livinguard in Switzerland are using the ASSURED framework.

Bombay Management Association (BMA) has institutionalised an award BMA 'ASSURED' Enterprise of the Year Award, which was won by Byju's in 2020.

The table below provides summary of how ASSURED Total Innovation model has been leveraged by various stakeholders in the innovation ecosystem.

India has the aspiration of emerging as a leading innovation nation. For this, India's innovation efficiency needs to increase very substantially, with maximum success in the mind to marketplace journey. The ASSURED framework proposed here provides a powerful instrument in the form of a proactive diagnostic tool. It's incorporation into the Innovation processes as also the entire innovation ecosystem will be extremely helpful in our efforts to lift India into the top league of innovation nations.

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December 2021, Volume 1, Issue 1

# Technology Renaissance
# A Peek into the Decade Ahead

**Vijaya Kumar Ivaturi,** Cofounder and CTO, Crayon Data

## Introduction

The world we live in has significantly changed in recent times. The assumptions we have made about the new growth models in business, the lifestyle we want to have and endure, and the planet dynamics have all been disrupted due to the pandemic. Therefore, 'Technology Renaissance' is an unusual title for an article about technology in a business journal.

Why should the term often associated with European renaissance make its way into the post-pandemic world as a technology renaissance? Well, it is important to pay attention to the underlying conceptual model for the renaissance here. During the renaissance period in Europe, the primary shift in thinking was to take responsibility for one's own actions in the context of rational behaviour. Self-interest and self-ownership for the successes and failures of one's actions was the underpinning of this movement.

## Global challenges, local solutions

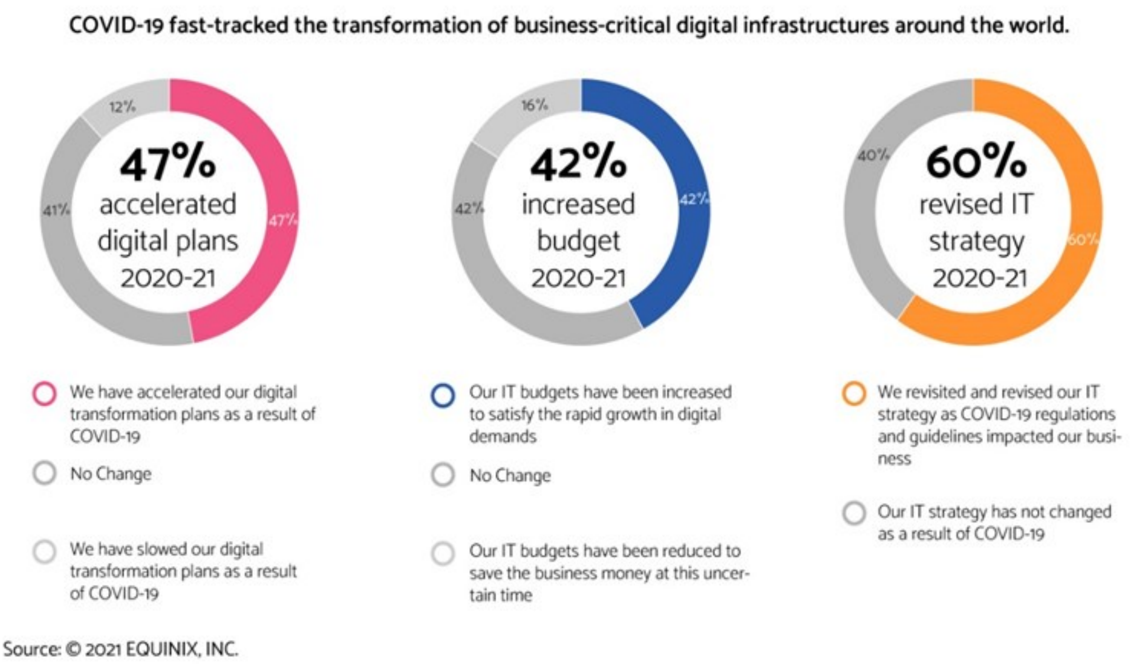
The current pandemic has proved that we are still vulnerable as a species and have not yet conquered, nor can we control, some of nature's forces. It has also shown us that we need to make responsible choices for developing and using new technologies. While the usage of advanced technologies has increased to counter many of the challenges we face today, it is also important to keep the human dimension in context to protect ourselves, as well as the planet we inhabit.

The decade ahead will push the limits of current technologies in addition to incubating new ones which have not yet been prioritised, or even thought of. The world is now global for challenges, but local for solutions. There are many common opportunities and threats we encounter together, but their solutions need to be tuned for each region's local context of social, political, cultural, and geographic factors.

## People, Planet, Peace, and Profit

A significant shift in recent times is that cyberspace is the new public space, and the physical space is the new private space. This shift redefined the boundaries of work, life, assets, collaboration, and ideological models for

**Figure 1**



everyone. Life today has also forced us to think cohesively in terms of People, Planet, Peace and Profit and mostly in that order.

The major technical shift is a Digital First approach to many of the solutions for our challenges in business, people, and planet. This has also made the process of developing new technologies to be more humane, relevant, and equitable to everyone, while pushing us to explore new frontiers in technology, which we would not have done otherwise.

There are many technologies which are in vogue today and evolving rapidly. Here is my list of key technology tracks which need a technology renaissance mindset: push the boundaries hard and be responsible.

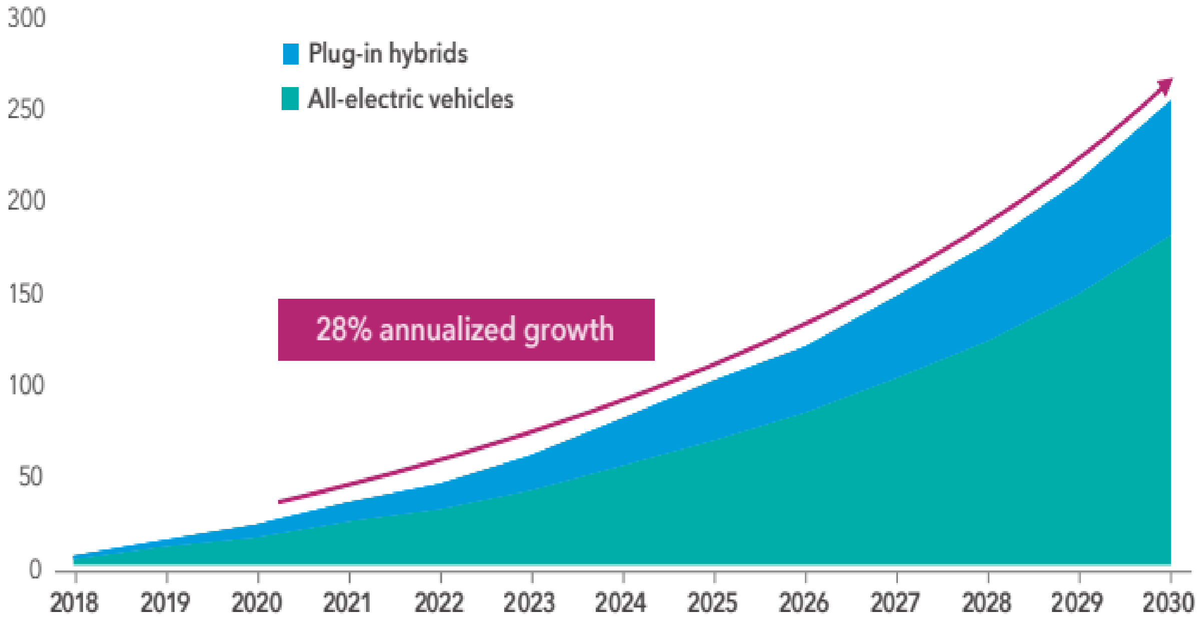
### Medical devices and diagnostic solutions

The advances in sensor tech, medical textiles, precision engineering, and wireless networks made many solutions a reality in remote diagnostics. The combination of sensor-driven biomarker acquisition, coupled with edge or cloud-based analytics, delivered diagnostic outcomes in near-clinical grade quality. As the world gets more connected and device driven, the boundaries of hospital-based care will blend with home-based monitoring and cloud-based clinical advice. The challenge is to define the point and value of a human touch, both in terms of clinical advice and patient empathy while designing these new age solutions.

### Autonomous vehicles and intelligent transport systems

The need for mobility for humans and assets is an old one, but the solutions evolved over centuries. Climate change is forcing us to abandon fossil fuel-based solutions and replace them with EV tech. While it is debatable whether EV is a green tech solution (as it uses rare earth elements), it is often argued that EV is a better choice in relative terms of carbon footprint. The combination of Cloud-based analytics with charging points solutions is a major shift to a connected vehicle ecosystem.

**Figure 2: Electric vehicle fleet worldwide (million units)**




Source: IEA, Electric vehicle stock in the EV30@30 scenario, 2018–2030, IEA, Paris. Data for 2020–2030 are forecasts, provided by IEA.

The grants and incentives from the Central and State governments, as well as advances in 5G networks, make this ecosystem intelligent and semi-autonomous. The trend to make these transport systems less human dependent in passenger mobility and human independent in cargo mobility is the reason for hot debates about human agency and control in transport systems and the legal liabilities involved in case of accidents. The subject of AI explainability, Ethics, Algo Bias and Inclusion principles is mainly driven by the point at which humans get back the control from the Bot and vice-versa. As someone said, "You do not need to drive to move, but just wish to move!"

## Synthetic Reality - Digital collaboration tools, AR/VR/MR

The emergence of new-age collaboration platforms during the lockdowns is an indicator for our need to interact virtually, but with the attributes of the physical world. This includes visual feel in 3D, aural appeal, tactile feedback, and background aesthetics. While it is not possible to replicate everything in cyberspace, it can get pretty close. The near-real feel is generated by Synthetic Reality, using a complex set of algorithms and attachments.

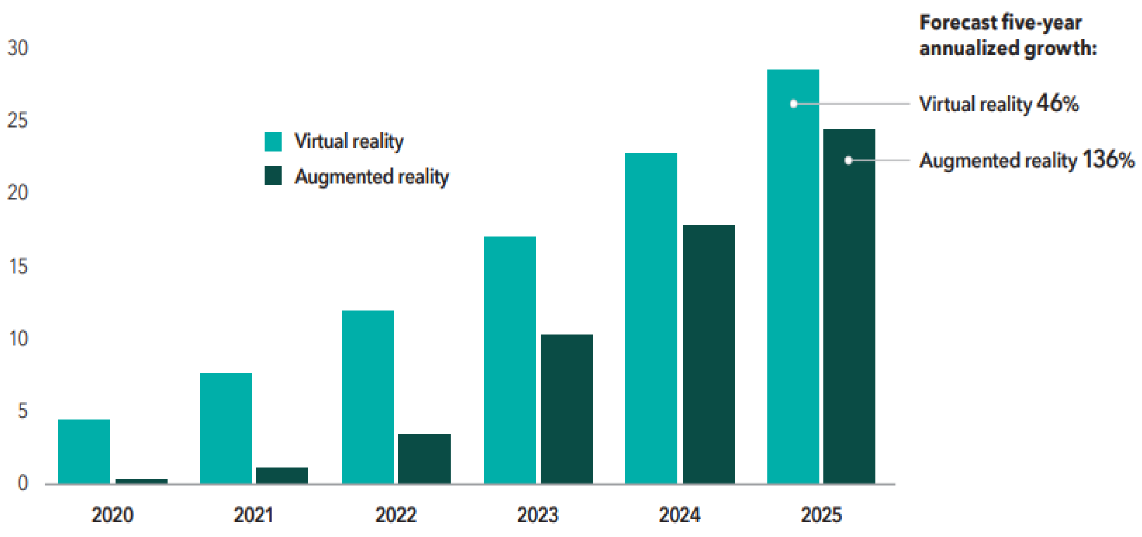
While the primary use case for people collaboration is well known in the recent times, there is a stronger use case for industrial or business use cases. It is possible to develop an entire subsystem while the rest is created with Augmented or Mixed Reality in high-precision engineering systems like spacecraft, defence systems, medical systems, and structural engineering.

The domain of AR/VR has existed for many years in an entertainment/gaming context, but now, it is one of the most popular fields for industrial systems where engineering precision is needed. The combination of AR/VR/MR and 3D printing makes this an interesting sector to watch out for as we deal with new age materials for flexible displays, advanced tech textiles and intricate surface geometries.

## Clean tech and LMA mining in Deep Space

The rise of digital technology adoption is driving the race to find faster and more efficient semiconductors. The ever-increasing need for more computing speed with lesser power consumption pushes us to explore options beyond the silicon-based transistors and gates. This drives the demand for rare earth elements,

**Figure 3: Worldwide hardware shipments (million)**




Source: IDC (report #US47225121). 2021-2025 are forecasts from IDC, as of January 2021.

as well as the exploration for new energy sources.

With Earth's sustainability in mind, the search goes beyond our planet, and this is what pushes us to explore deep space horizons. The famous Lunar-Mars-Asteroid arc (LMA) is a case in point. The demand for deep space probes, rovers and industrial grade eco-planet miners is driving new age space start-ups and challenge-based funding like NASA or Google programmes. A few years ago, nobody would have given a thought to deep space mining for helium. But now, the thrust is to build new space communication systems and industry grade landers and excavators to source energy inputs. The convergence of clean tech, wireless and Deep Space projects is an interesting one to watch out for.

## Digital engagement - Sports, Finance, Education, Entertainment, Government

The ubiquitous argument about user engagement is that a user's experience is always an analogue one, while the channel is digitized. The pandemic and remote working pushed the envelope for digital-based engagement for most sectors. And more so in finance, sports, education, entertainment, and government sectors. The default onboarding now is digital, and mobile-based in specific for many utilities and services in our daily life.

This shift forced us to be more inclusive in nature, as the digital engagement moved from a niche offering into a mainstream and default offering for such services. This begets the question of human touch again in the process flow, as well as for emotional connect in these systems. It raises pertinent questions about anonymity, privacy, security, and agency in digital transaction systems.

The paradox is that the dataset and workflow for a great user experience often comes at the cost of user privacy or anonymity. The popular debates of privacy versus national security and privacy versus personalisation will keep raging, as the context differs from user to user, while the policies are applicable across the board. The model for levels of consent and digital/rights literacy that is assumed for the same is a case in point. Digital technologies can do wonders for the experience wheel of a user in any of these domains, but it is often a debate on how helpful it is versus how intrusive it is. Digital voyeurism is euphemism for personalisation or intrusion based on what one believes in! As an anthropological enquiry, it is still an open debate whether digital societies or clusters based on transactional relationships exhibit a culture or learn one. In a physical world, there is only ONE person. But one can have many digital personas in the cyberworld, resulting in polymorphism of personality. Digital persona is based on what one wants to be, rather than what one is in the real world. This challenge of identity and authenticity in digital engagement is an evolving one in social anthropology of digital world.

To loop back to the topic of this article that is Tech renaissance, the challenges and opportunities of the above technology domains force us to reflect on what enlightenment we want in terms of technology - a peek into self for a better life of peace and 'Live & Let Live' motto?

CII STRIDE

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# Sustainable Digital Age A Perspective

**Santosh Mohanty,** VP and Head, IP and Product Engineering, TCS

## Abstract

*Sustainable development is the process of moving human activities to a pattern that can be maintained in perpetuity. Sustainable concerns spring from techno-economic, eco-centric, and socio -centric activities. To achieve sustainable characteristics, on a fast track, with resilience, we need to digitise organisational processes, automate the execution of enterprise tasks, build cognitive intelligence to be uniquely responsive to users, and manage changes with effectiveness. This makes software and data an integral part of every walk of a person's life. That is why the triad of people, software and data needs to be managed with the following sustainable characteristics— Efficient, Adaptable, Agile, and Anticipative.*


## Introduction

It is increasingly recognised that many of the practices and lifestyles of modern society cannot be sustained indefinitely. Sustainable development seeks to identify issues related to environment, development and service that aim to reconcile human needs with the capacity of the planet to cope with the consequences of human activities.

This article intends to focus on providing a holistic view of sustainability in a **Digital Age**. To begin with, we need to understand sustainability concerns and address them while designing the approach to mechanisation and personalisation in a **Digital Age**. The sustainability aspects of software development, software delivery, context-driven data analysis, and service-oriented data management are also discussed in this paper.

## Sustainability Concerns

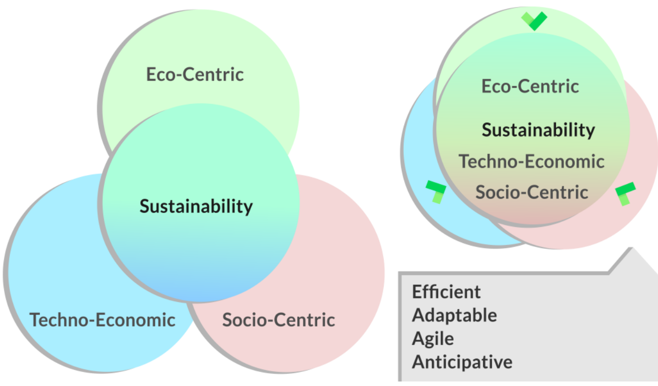
Sustainability concerns can be broadly categorized under three buckets:

- **Techno-economic concerns**: It encompasses techno-economic systems, represents human skills and ingenuity - the skills that humans must continue to deploy and the economic system within which we deploy them.
- **Eco-centric concerns**: It represents the ability of the planet to sustain us - both by providing material and energy resources and accommodating us and our emissions and wastes.
- **Socio-centric concerns**: It represents human expectations and aspirations—the needs of human beings to live worthwhile lives – a better quality of life for everyone, now and in the future.

Sustainability can be thought of as the direction where all three sets of constraints are satisfied, while sustainable development is the process of addressing each of the concerns to enable us to move in the direction of sustainability.

Although a figurative representation, figure 1, is simplistic, it reminds us that sustainability means living within the boundary of all three types of long-term constraints. We must review the use of technology for environmental or societal implications. Therefore, people play a key role in sustainable development, with the obligation to fulfil societal responsibility, ably supported by their knowledge, expertise, and technology adoption.

**Figure 1: Sustainability Concerns**



## Approach to Mechanisation and Personalisation

Within the purview of sustainability, let us understand the aspiration of humans and society at large. Today, every field presents unlimited opportunities and limited people with the right skills to address these opportunities. Every consumer expects undivided attention, reliable services and high quality, durable products for use. Achieving such results needs a continuous strive to achieve maximum mechanisation. It means we must:

- Maximize machine-to-machine interaction
- Balance machine-to-people interaction
- Reduce people-to-people interaction

At the same time, to deliver a personalized experience, the system should have the capability to understand the profile of the individual or entity and perform tasks that best fit the context.

The foundational capability that will drive and optimize the fine balance between mechanisation and personalisation is understanding these terms and appropriately adopting the technology. The policy-driven processes that facilitate the real-time, rule-based, and format-based execution and an integrated technology backbone are the key drivers in delivering sustainable characteristics—**Efficient, Adaptable, Agile,** and **Anticipative.**

- **Efficient**: Better in Quality and Cost Affordability; Highly productive management of resources—Natural, Physical, Engineering, Computing and Human
- **Adaptable**: Ability to address adjacent problems with efficiency
- **Agile**: Ability to respond or to produce material/output/product/process fast with high efficiency
- **Anticipative**: The product/solution available or the process practiced can remain attractive for a longer period 'as-is' or with 'minimal changes'

**Figure 2: Mechanisation and Personalisation**

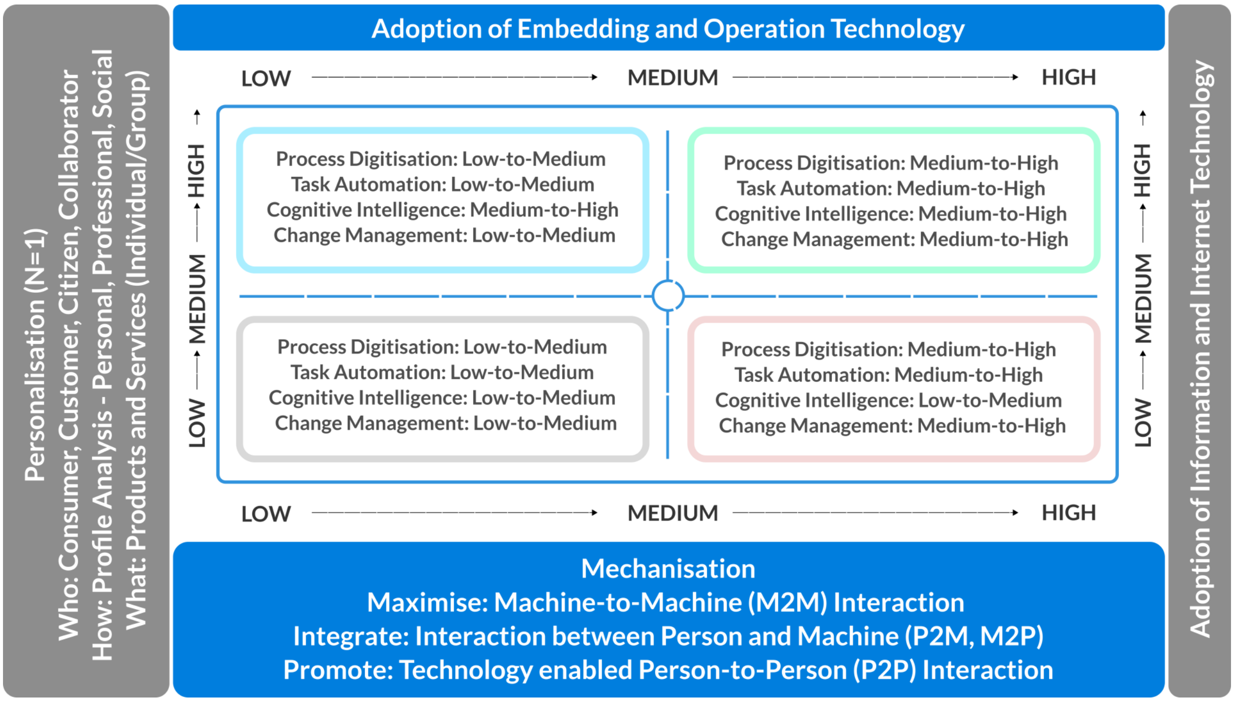
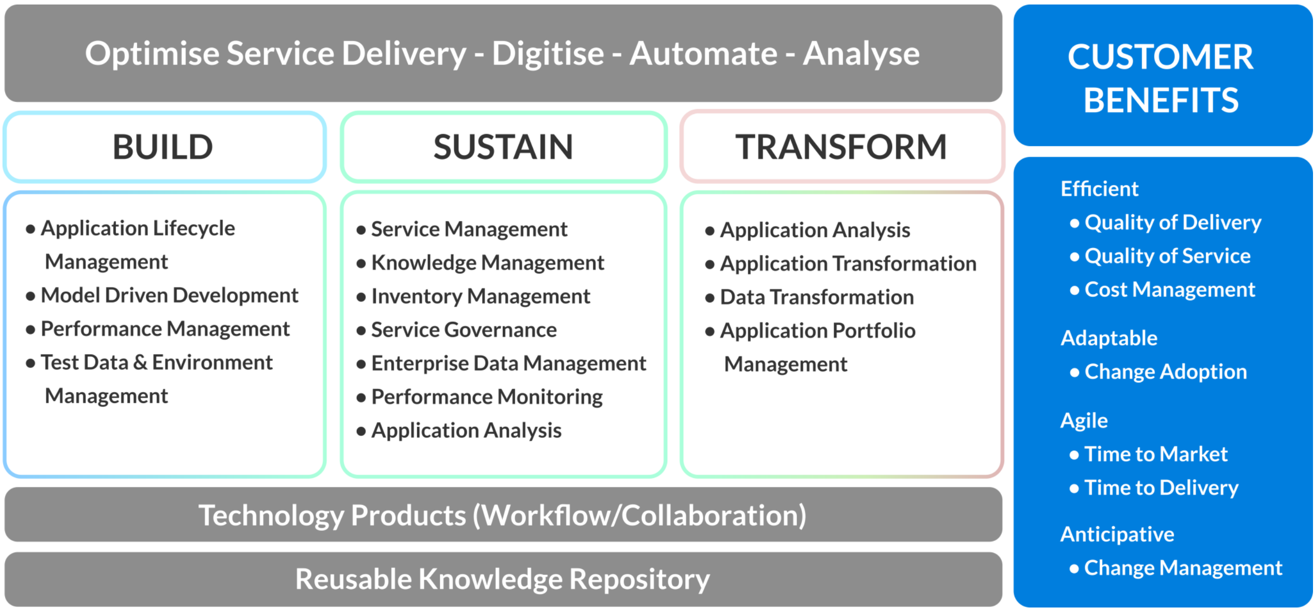


Figure 3: Business architecture for developing, supporting, and managing software




To achieve sustainable characteristics on a fast track with resilience, we need to digitise organisational processes, automate the execution of enterprise tasks, build cognitive intelligence to be uniquely responsive to users, and manage changes with the same effectiveness. We also need to take advantage of resources and their availability for consumption by deploying technology and managing resources through digital technology and smart governance. This can be achieved if each resource is driven by smart software with a philosophy of 'software-driven things' (for example, software-driven radio, software-driven refrigeration, software-driven automotive) and effective utilization and management of these resources through the Internet of Things. Figure 2 , on the previous page, demonstrates the conundrum between Mechanisation and Personalisation.

## Sustainable Software Development

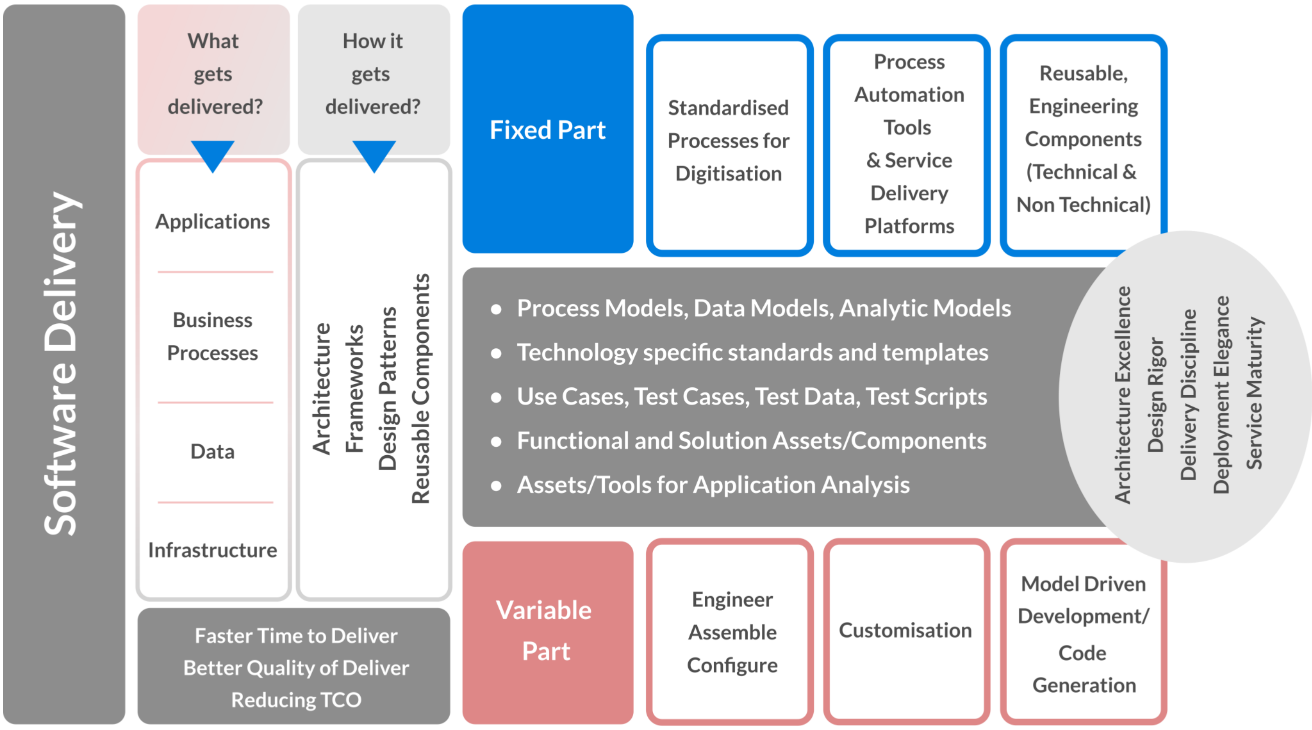
As software is becoming an integral part in every walk of life, the software development cycle must adopt the same sustainable characteristics—**Efficient, Adaptable, Agile,** and **Anticipative**. The business architecture for developing, supporting, and managing the software is depicted in Figure 3.

## Sustainable Software Delivery

The software delivery cycle covers architecture, design, development, release, deployment, and maintenance service. The adoption of the following practices will lead to sustainability in software delivery.

- **Digitisation of life cycle processes**—standardise, componentise, collaborate and share
- **Automation of repeatable tasks**—both engineering and process tasks
- **Collaboration platform** to bring collective knowledge towards innovation and completion of tasks
- **Analysis of the generated data** due to digitisation and automation to draw inferences and insights to improve quality and speed of delivery and support

**Figure 4: Sustainable software delivery system**




The Figure 4 depicts sustainable software delivery. The key is to achieve excellence in architecture, factoring it to design with rigor, practicing design artefacts as the basic discipline during delivery, ensuring elegance of deployment, and demonstrating service maturity during support. This must result in faster time to deliver, better quality of delivery, and effective management of Total Cost of Ownership (TCO).

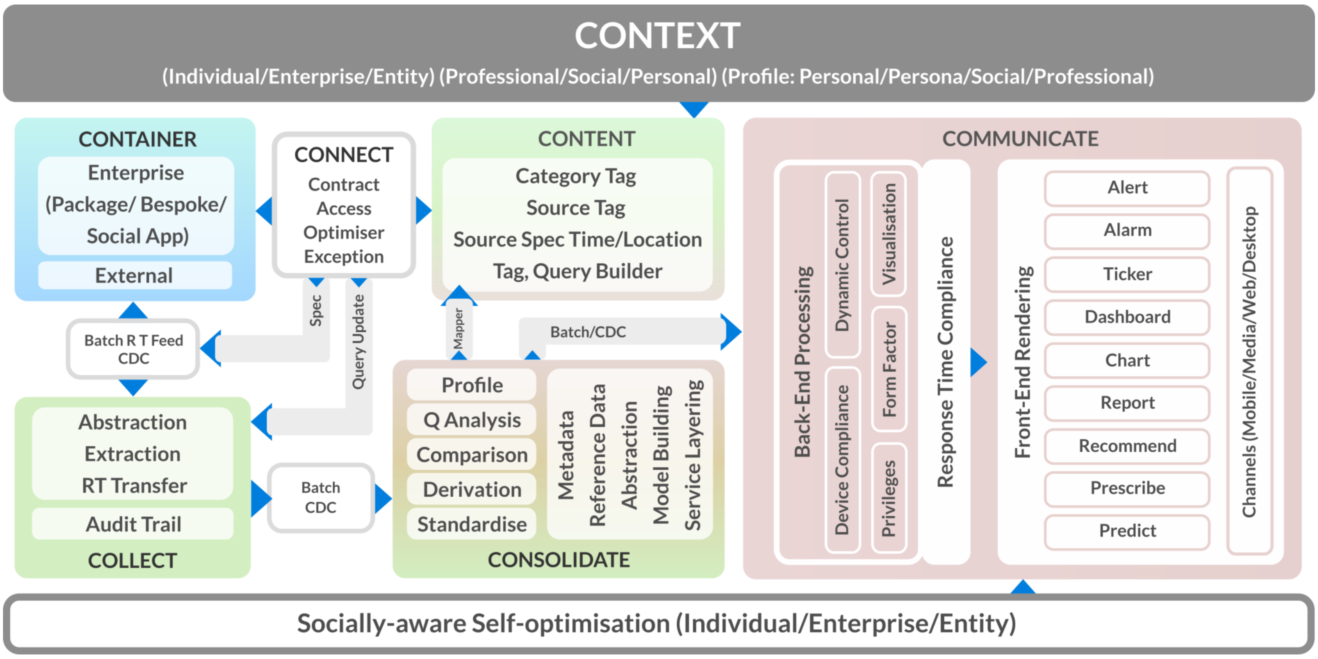
## Context Driven Data Analysis

As the adoption of technology is growing along with adoption of software, it results in the generation of significant data in digital form. This data, along with social networking data, provides a unique opportunity to analyze and implement data-driven recommendations towards the improvement of digital business architecture. This, in effect, delivers personalised value to each stakeholder. To enable this, the capability needs to be built with the principle of '**7Cs**'.

- **Context** understanding
- **Content** that need to be searched and analyzed
- **Container** from which it must be collected
- **Connection** privileges to those containers
- **Collection** of content
- **Consolidation** of content
- **Communication** of content based on context through user-expected format.

Figure 5, on the next page, provides a view of solution architecture towards context-driven data analysis.

**Figure 5: Solution architecture towards context-driven data analysis.**



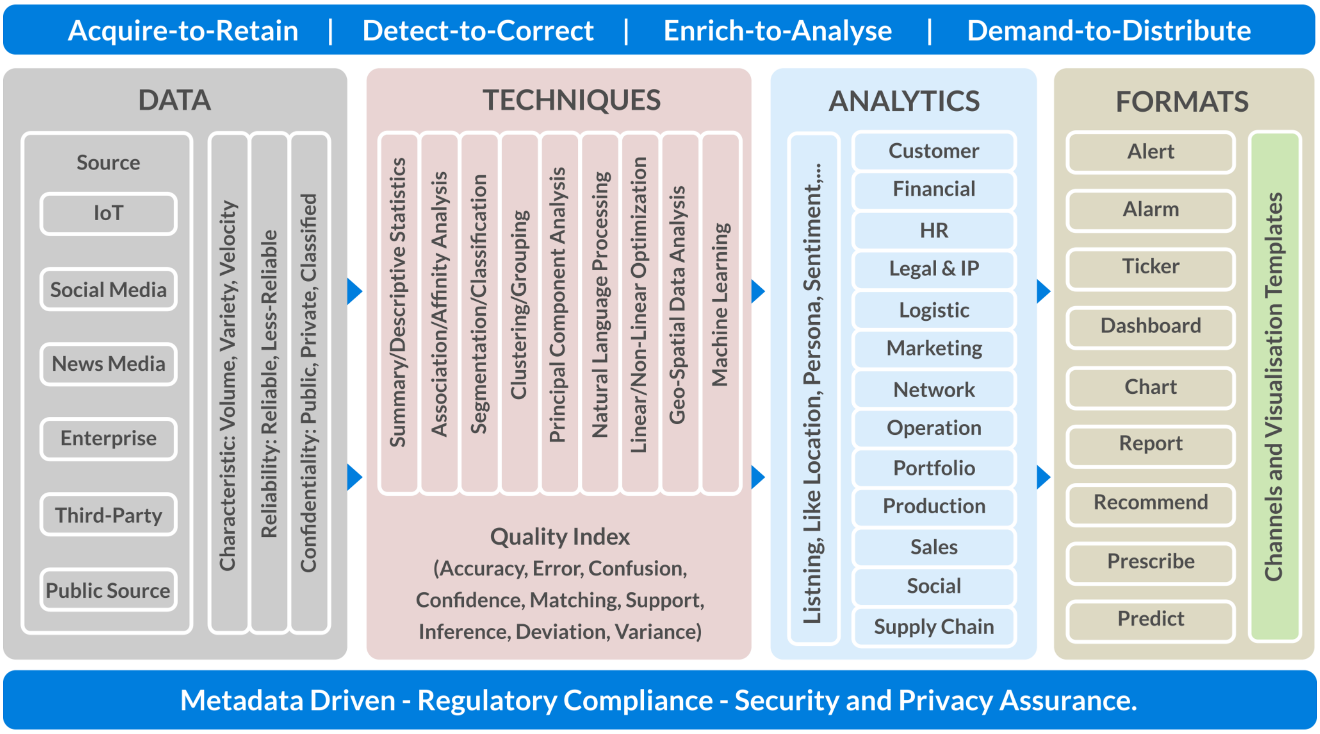

## Service-oriented Data Management

A data management platform will be the core to develop and manage a **Connected Enterprise** in this **Digital Age** that will seamlessly integrate people expertise and machine capability to deliver contextual insights and outcomes that are **Efficient, Adaptable, Agile,** and **Anticipative**. There are four value streams of the Data Lifecycle Value Chain that an enterprise needs to manage to maximise business value of a data management platform. These value streams are:

- Acquire-to-Retain: This value stream enables acquisition of data from myriad data sources using varied data formats and different integration technologies. The data may be sourced on real-time basis or in batch mode. The data is retained in an enterprise standard format and hence, there may be a need of conversion.
- **Detect-to-Correct:** This value stream performs auto-verification of data, identifies potential anomalies, and carries out necessary corrections, thus improving data quality. It involves sanity checks for completeness, conformance, and integrity. It also performs more complex historical correlations, matching algorithms, and de-duplication logic.
- **Enrich-to-Analyse:** This value stream deals with enriching data by adding derived data as well as abstracting data to higher up hierarchies. It also includes capabilities to plug-in advanced analytics and large-scale data processing capabilities as bolt-on functionality. The advancement of this value stream should enable enterprises to move from descriptive analytics to predictive and prescriptive analytics.

**Demand-to-Distribute:** This value stream involves provisioning of data insights to right stakeholders in the value chain (people, product, system, network, infrastructure, logistics, and so on) at the right time. The business strategists need to gain access to

**Figure 6: A reference architecture of data life cycle flow in a Data Management Platform**




advance data analytics on vast amount of historical data to strengthen the process of taking strategic decisions. The operation managers need real-time data insights with historical correlation to automate or inspect right actions. The Figure 6 depicts a reference architecture of data life cycle flow in a data management platform.

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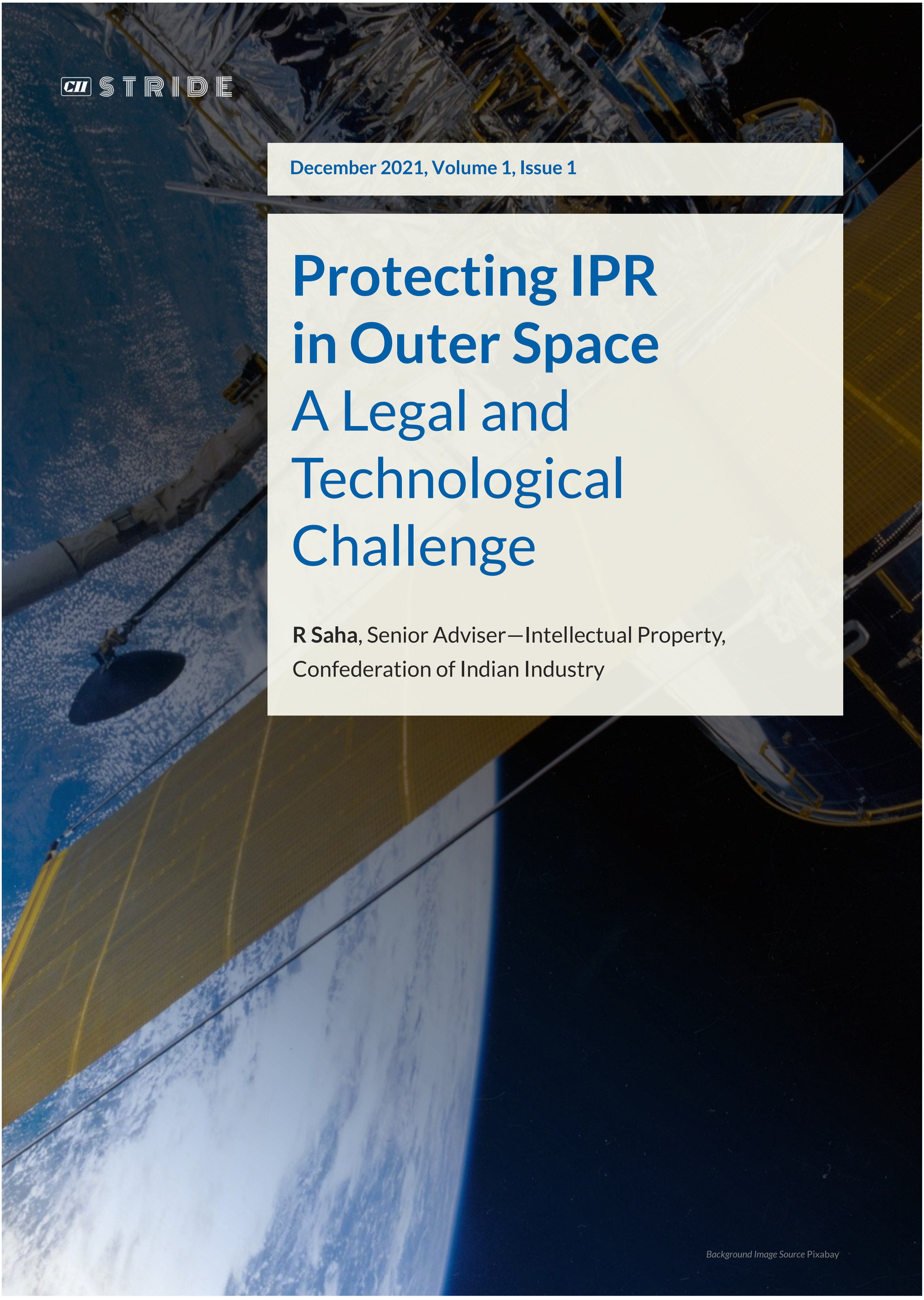


December 2021, Volume 1, Issue 1

# Protecting IPR in Outer Space
# A Legal and Technological Challenge

**R Saha**, Senior Adviser—Intellectual Property,
Confederation of Indian Industry

*Background Image Source Pixabay*

The initial spirit of exploring outer space starting with the first space flight by Sputnik in October 1957 got metamorphosed into more extensive exploration of outer space and terrestrial bodies, research activities and sensing of commercial interests, over the years. The insatiable and unending human spirit to know the unknown and the advancement in science and technology have been the main drivers. Telecommunication and navigation have established an undisputed position in outer space for commercial and strategic interests and now space tourism, the utilizing materials of terrestrial bodies and collaborative research in space stations have added new dimensions.

All space activities whether exploratory or commercial, undertaken by nations and companies are presently governed by two international treaties namely, the Outer Space Treaty of 1967 and the Moon Treaty of 1979 which have their origin in the Cold War Period. The central theme of the Outer Space Treaty was to allow and regulate peaceful use of outer space and terrestrial bodies without claiming any ownership of any resources, appropriation of any part of space and undertaking military or military like activities. India and all space nations are signatories of this treaty. It is also stipulated that space exploration and use shall be carried out for the benefit and in the interests of all countries. This therefore prevents the sale of space-based minerals for profit. The treaty also states that outer space shall be the province of all mankind. The Moon Treaty has, in effect, forbidden states to conduct commercial mining on planets and asteroids until there is an international regime for such exploitation. It allows freedom of scientific investigation on the moon. However, it may be noted that India is not a signatory of the Moon Treaty and so are other space nations such USA and China. The thoughts of this treaty will certainly get reflected in any future international discussions. Protection of IPR is not an element of these treaties as commercial activities were not visualized at that time.

Several countries including India, are studying promulgation of a legal framework to allow private entrepreneurs to undertake space activities as also how IPR could be protected in the outer space. The draft Space Activities Bill 2017 proposed by ISRO carries a section on IPR. USA extended the reach of its patent laws to US registered spacecraft by enacting 35 USC Section 105. This Section provides "any invention made, used or sold in outer space on a space object or a component thereof under the jurisdiction or control of US shall be considered to be made, used or sold within US". According to the US Space Act 2015 US citizens may engage in the commercial exploration and exploitation of space resources. USA has recently shared its vision in the Atlantic Council to overhaul the UN treaties for facilitating space activities for commercial purposes. **It is expected that investments and other efforts towards undertaking commercial activities in outer space would grow in coming days. If no IPR protection is provided, why would any company invest resources and time in undertaking any outer space activity? If no company comes forward, space resources such as Helium 3 cannot be utilized for the benefit of human race.**

We all know that outer space is being utilized for commercial and strategic purposes for many decades now Especially for satellite communication and navigation.

Are patents being issued for inventions useful in exploring outer space and exploiting the same for satellite telecommunication and navigation? The answer is yes; one of the first few patents was issued in USA in 1961. Since then, few thousand patents have been granted (based on my searches). How many of these are enforceable in outer space is a million-dollar question? It is a complex subject involving orbit selection, orbital dynamics, satellite designs and their control in invisible physical space. Apparently, orbits themselves are not patented but systems incorporating technological solutions, special materials, electronics etc. for telecommunication are the subject matter of patents. The Molniya orbit originally designed by Russians is one such orbit used frequently by the aerospace community as this orbit maximizes the time satellites can spend over the northern hemisphere.

IPR concerning outer space would primarily be the outcome of research carried out on Earth and research conducted in outer space and on celestial bodies. The former is easy to handle as it is governed by the existing IPR laws in each country. Territoriality and sovereignty are at the centre of all existing IPR laws. There is no globally accepted definition of the starting point of outer space. However, many aerospace enthusiasts consider the Karman Line, which is 100 km above the sea level, as the beginning of outer space. The present jurisdiction of countries for civil aviation activities is only up to a few kilometres above the Earth. Outer space is thus beyond and outside the territory of any country, and any sort of appropriation is not legally possible and sustainable. Hence, applicability of IPR laws practised on Earth to outer space is froth with legal and technological challenges.

The question of jurisdiction in outer space is not easy to answer. What could be the legal grounds for ascertaining jurisdiction, which transcends the boundaries of IPR laws?

Let us look at the following situation. Consider a company A which lands on moon, collects soil samples or some other material and then files a patent based on these raw materials in a country on Earth. Can a patent be granted under the existing international space laws / treaties? How would such IPR be enforced both in outer space and on the Earth? The first question would be why not? The second would be no and the third could be yes provided the patent immediately after grant, is placed in the public domain for its use by others without the risk of infringement. The third choice may perhaps, satisfy the broader goals of two treaties mentioned above.

There are plenty of questions and few are being raised here. Can inventions made and patented on Earth be used by others in space freely without the risk of infringement? How do you apply the criterion of inventiveness and non-obviousness in respect of inventions made in space? Non obviousness demands that the invention should not be obvious to a person skilled in the art. It would be difficult to find such a person as the environment of experiment in space may not be created on the Earth. Similarly, the requirement of enablement and adequate disclosure may be difficult to meet as it would require undue and expensive experiments to work an invention backwards.

One can carry out different types of scientific research in space, especially taking advantage of zero gravity or weightlessness as there is no human effort in creating the environment. Do the research results under this circumstance qualify for a patent? Whether the application of IP laws to outer space activities is a breach of the State's obligations under the treaties? Many more questions other than the above need to be answered for expanding the commercial (and strategic) use of outer space and terrestrial bodies. Collaborative research in International Space Station may provide partial answers to some questions.

Infringement, of patents and other IPR granted on Earth, in outer space is a serious matter for companies to guard against. Can an amicable solution be found through novel licensing arrangements which are applicable in outer space?

IPR issues will start multiplying after a few years when commercial activities grow in numbers. One can sense emergence of litigations.

**Do we need an extension of the existing IPR laws to outer space or design a new legal framework for IPR protection in outer space? Should a common legal system be developed for IPR protection on Earth and outer space simultaneously?** Should a body like International Civil Aviation Organization (ICAO) be entrusted to look into the issues and suggest solutions? The world faces a grand challenge!!!

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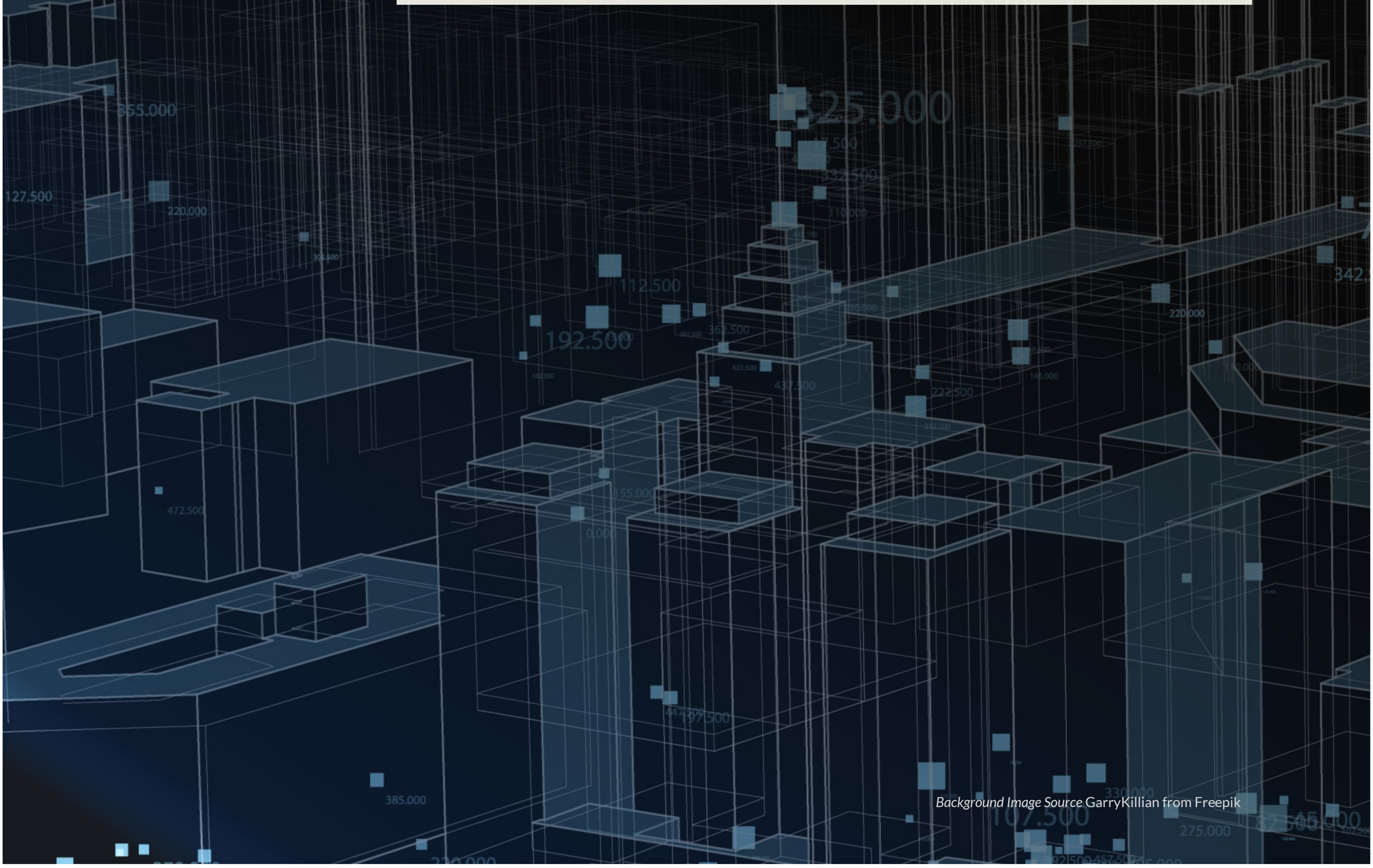
# Re-shaping India's National System of Innovation
## Lessons from Taiwan

**N Dayasindhu,** Co-founder and CEO, itihaasa Research and Digital

**Rishikesha T. Krishnan,** Director and Professor of Strategy, IIM Bangalore



*Background Image Source* GarryKillian from Freepik

## National system of innovation

Technological innovation is a means to fulfil a human purpose.  The result of technological innovation are shifts in the production function that play an integral role in the economic development of countries and companies. Innovations that create new technologies are often a result of complex interactions among Government, universities and labs, different sectors of the economy, and institutional mechanisms.  These interactions happen at multiple levels – company, industry, or country. A national system of innovation is an important interaction model at the country level.

**A national system of innovation is a set of organizations and institutions that individually, and more importantly, jointly contribute to the development and diffusion of emerging technologies and provides a framework for policy making to influence the innovation process.** Organizations include, those that are involved in basic research, development, its translation, and those that create user applications. The interconnection among organizations is a critical factor that influences the creation, storage, and knowledge transfer behind new technologies.

The national system of innovation involves different organizations; Government, Government laboratories, universities, industry, startups etc., working in collaboration. Although, there is a formal division of labour among the different organizations constituting the national system of innovation, informal networks and institutional mechanisms are important routes for transferring the more tacit technical knowledge. The nationality aspect is rooted in the shared vision, culture, and policies and the institutional frameworks that define the innovation environment.

The role of institutions in shaping technology is important. Institutions or "the explicit and tacit rules of the game" are important elements in establishing the national systems of innovation. While institutions are difficult and costly to establish, they assist interactions among various parts of the national system of innovation and help build a national capability in emerging technologies.  The national system of innovation is thus a continuously evolving system that needs to adapt to the socio-economic needs of a country.

## Taiwan's national system of innovation in semiconductors

In 2020, Taiwan - smaller in area than Kerala with a population less than that of Haryana – had about USD 54 billion worth of semiconductor contract manufacturing (63% global market share) compared to about USD 5 billion (about 6% market share) for China, the factory of the world.   More importantly, Taiwan has a five-year lead in this technology over China. For example, the first Chinese company Semiconductor Manufacturing International Corp (SMIC) started producing 28nm semiconductors in 2017 while the Taiwan Semiconductor Manufacturing Company (TSMC) began producing the same in 2012. Not surprisingly, TSMC today dominates the semiconductor foundry industry with about 50% market share.  There are two companies in the world that have the capacity to produce state-of-the-art 5nm semiconductors at scale and one of them is TSMC.

Taiwan's current prowess in semiconductor manufacturing can be traced to the national institutions that nurtured research and talent in semiconductors without depending on excessive foreign aid from the 1970s. The

Taiwanese semiconductor industry owes its origins to K.T. Li, Chairperson of the Science and Technology Task Force (STAG) and to Y.L. Sun, a Minister in the Government of Taiwan. K.T. Li was a physicist who served as the Minister of Economic Affairs and Minister of Finance while Y.L. Sun was a national leader who was Minister of Economic Affairs and went on to become the Premier. The STAG was a group of largely foreign experts - affectionately called the 'foreign monks' - who identified potential technology strategies for Taiwan.

Sun also conferred with Taiwanese origin semiconductor professionals in the USA and decided that it was a good bet for Taiwan's future development. The strong social relationships between Taiwanese in the USA and policy makers and technocrats in Taiwan resulted in a knowledge transfer on how to start an electronics industry in Taiwan.

There were no applied research labs in Taiwan in the early 1970s and the Government set up the Industrial Technology Research Institute (ITRI) in 1973 for building and transferring technological capabilities in electronics, computing, communication and aerospace. Electronics Services Research Organization (ERSO) the electronics arm of ITRI was started in 1974.

Taiwanese technocrats on the advice of Taiwanese origin semiconductor professionals in the USA took an important technology decision to develop a semiconductor industry using the emerging technology termed as metal oxide semiconductors or (CMOS) technology in the late 1970s. This perhaps was the single-most important decision that paved the way for Taiwan's dominance in the global semiconductor industry. Making a bet on CMOS that had a small market share in the 1970s was the correct choice since it became the dominant semiconductor technology in the future.

The Taiwanese origin scientists also helped ITRI/ERSO to acquire an outdated chip fabrication technology from RCA in 1976 that ITRI/ERSO improved upon by a series of process innovations. In fact, ITRI/ERSO blurred the lines between R&D and manufacturing. This resulted in a capability in semiconductor manufacturing that was easily transferrable to an industrial setting. ITRI/ERSO also recruited Taiwanese engineers and sent them to RCA for a year's training in their foundry. The Taiwanese government simultaneously set up science parks to provide world-class infrastructure while large companies worked with specialist medium and small specialized global suppliers.

**The intertwining of Government research labs and industry is important to translate new technologies from the labs to the market.** The Hsinchu Industrial Park in Taiwan was created in 1980 to provide world-class infrastructure for the semiconductor industry. At present, Hsinchu accounts for a significant global supply of semiconductors. The first organization that was set up in Hsinchu was United Microelectronics Corporation (UMC) in 1980. The Government of Taiwan held a 49% stake in UMC and most of the senior technical staff were from ERSO who were also responsible for the technology plan of the organization. The Government's motivation for starting UMC was to translate the research and capability built in ESRO to set up a company and then an industry. Many successful companies in Hsinchu owe their origin to ERSO. The next big leap for the Taiwanese semiconductor industry with the creation TSMC in 1986. It was conceptualized as a foundry for third parties especially the foreign semiconductor firms who did not want to invest money in semiconductor manufacturing. Morris Chang who was the President of ITRI after a long and successful career in the semiconductor industry in the USA was TSMC's founder. TSMC initially acquired technology from Philips but soon internalized the manufacturing technology.

## Learnings for India from Taiwan's experience in creating a national system of innovation

First and foremost, India needs to choose strategic emerging technology areas that we will focus on. This is akin to how Taiwan chose to focus on CMOS technology and built its capabilities to became a global leader. The Office of the Principal Scientific Advisor has identified a few areas including artificial intelligence embedded technologies, quantum technology, semiconductor technology, smart manufacturing technology, future of transportation, advanced communication technology, and block-chain based technology. In addition, the Department of Science and Technology has identified water and clean energy, nano science and technology, and supercomputing. The key is to focus on a few and create national system of innovation in those chosen domains.

Second, is to nurture knowledge transfer among research institutions and academia in one hand and industry on the other. ITRI/ESRO's knowledge and people transfer helped to build Taiwan's first semiconductor company UMC. The relationships and knowledge transfer between the constituents of the Hsinchu Industrial Park is among main reasons for Taiwan's success in the global semiconductor industry. We saw that TSMC was started by a former head of ITRI. And TSMC invested in Vanguard International Semiconductor Corporation (VIS) and used them as a subcontractor. Today (VIS) is one the largest global foundries.

While India has traditionally had mixed success in these type of knowledge transfers, the future looks promising. The Indian draft Science Technology and Innovation Policy 2020 (STIP 2020) mentions establishing Collaborative Research Centers (CRCs) to bring together participating stakeholders. The policy focuses on all the different types of research and technology transfer collaborations. Industry collaboration along with collaborative modes of industry funding for research projects also seems to be on the anvil. More programs like Visiting Advanced Joint Research (VAJRA) and GIAN (Global Initiative of Academic Networks) are planned to foster international collaborations. If implemented well, these programs can move the needle in developing a world-class research and translation capability with participation from many sectors of the economy leading to national systems of innovation. **The Taiwanese experience shows us that overlapping R&D with industrial applications makes translation happens naturally and seamlessly rather than arduously as an after-thought.**

Third, and most important is to develop a strong cadre of professionals in the chosen emerging technology domains. In the Taiwanese context, ITRI/ERSO acquired an outdated chip fabrication technology from RCA in 1976. The focus of research in ITRI/ERSO was to improve this acquired technology by a series of process innovations. Taiwanese semiconductor professionals especially in the USA were instrumental in arranging training Taiwanese professionals with the latest developments in semiconductor technology in this era. This includes the transfer of tacit knowledge – which includes experts elucidating how they make decisions on technology and processes. These aspects of tacit knowledge transfer are also enshrined in STIP 2020. The objective to achieve technological self-reliance and position

India among the top three scientific superpowers in the decade to come is an aspirational goal for young Indian R&D and technology professionals to strive for. This will go a long way to attract, nurture, strengthen and retain critical human capital through a 'people centric' science, technology, and innovation ecosystem. The ambition to double the number of full-time equivalent researchers every five years is good only if there a minimum world-class threshold set for researchers. And while it is important to focus on research, **India should also include developing a strong cadre of technologists who will translate the research in emerging technologies into applications in an industrial setting. It is vital to ensure that the excellent vision is translated into action.**

The immediate roles of Indian industry in nurturing a vibrant national system of innovation are three-fold. First, industry must get plugged into and actively participate in national R&D networks. Their role is to provide market feedback and ensure Indian R&D is also focused on translation into commercial applications. Second, as part of national system of innovation, industries will have to create and nurture clusters of companies with different expertise that can collaborate with each other to develop and produce world-class end products. Third, industry also needs to support funding R&D along with the Government. Our current levels of Gross Domestic Expenditure on R&D (GERD) is about 0.65% with about 37% contribution coming from industry.

**An immediate priority is to increase industry contribution as India aims to increase GERD to about 1.5% to 3% which is in-line the top ten global economies.** Industry's contribution to GERD in these economies is at about 68%. While is impressive that India entered the top 50 innovating countries for the first time in 2020 since the inception of the Global Innovation Index (GII) in 2007, we still have work to be done to catch up with the global leaders.

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# Delivering on the Promise of Industrial IoT (IIoT)

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## Abstract

*Industrial Internet of Things (IIoT) has been touted as the technological wave that will augment the world economy bringing jobs and GDP growth across countries. However, in industry after industry, IIoT has failed to deliver on the promise of providing disruptive value through improvements in yield, efficiencies, and costs. The author argues that mere data capture at the plant and analysis of the data in the cloud will not unlock the power of IIoT. The arrival of mature Edge computing enables an Edge AI IIoT strategy which completes the value loop along with advanced sensors, AI, and 5G. The data collected by the sensors with a closed loop control through advanced AI inferencing right at the edge will enable IIoT to deliver on its promise.*


## Introduction

Industrial IoT (IIoT) has not lived up to the promise of 50 billion connected industrial things delivering a 10 trillion-dollar economy as touted by large industrial companies over the past decade. The reasons are part technical and part organizational.

## The Technology Side

On the technology side, stationary industrial things have been connected for over 50 years. Industrial equipment was inter-connected with cables and wires—data flowed, was analysed, and displayed. Many entities also had closed-loop control as well. Hence, the intranet of things existed even before the internet itself. The programmable logic controllers (PLCs), the distributed control systems (DCSs) and the supervisory control and data acquisition (SCADA) systems still perform well and continue to deliver. The IIoT solutions offered by companies are, typically, nothing more than glorified headquarter reporting tools. Unless there is a plant level problem being solved or a shop-floor process being completely replaced, industries will not accept the story of adding multiple wireless sensors and displaying countless data screens.

## The Organisational End

On the organizational end, typical industries have operations technology (OT) teams at the plant or shopfloor, Information Technology (IT) teams located at the corporate headquarters, and corporate data science (DS) teams with an independent reporting structure. These teams are not incentivized to cooperate for long term success. Irrespective of the industry, the plants have a short-term focus on production, the IT departments are optimizing costs, and the data science teams do not have domain expertise. In a typical IIoT setup, the OT teams provide challenge statements, the IT teams provide cloud servers for big data, and the data science teams crunch the data in an off-line mode. Practically, however, organizational barriers do not permit IIoT to deliver on its promise. Off-line outcomes from data science teams are rarely implemented by the plant. IT is satisfied by producing reports for the headquarters. And the headquarters wonders why the IIoT implementation is not producing results. There is very rarely a unified solutions approach to completely redesign the plant for better yield and efficiency, leveraging new technology.

**The technologies that will help IIoT deliver its promise are miniaturized sensors, artificial intelligence (AI), edge computing, and 5G.** This will have to be matched with clear roles for the OT, IT, and the DS teams. Combining these aspects, an Edge AI IIoT strategy will enable improvements at the plant, using edge devices installed in the equipments and provide automated real-time process control based on data insights at the Edge. This completes the loop, providing local control, while leveraging the IT cloud infrastructure for AI training and longer-term storage. While, the data sciences teams provides algorithm updates over the air to the plant, the Edge AI IIoT strategy should at the minimum target:

- a 2% factory yield improvement, or
- a 25% process energy efficiency improvement, or
- a 10% savings in operations and maintenance costs.

Currently, AI is defined in very broad terms. All approaches including, expert systems, statistical systems, and machine learning systems have their value. It should be noted that the current excitement about AI is driven by the abilities demonstrated by convolution neural networks and deep neural networks. Especially, the abilities of these approaches in handling voice, sound, image, and video enabled transformational outcomes. The Edge AI IIoT strategy will be able to deliver the transformational changes at the plant, only with the incorporation of neural networks and the ability to deal with unstructured data.

**A good place to start in building an Edge AI IIoT strategy is to answer the following questions:**

- What data does the plant/shopfloor currently produce or can generate?
- Which manual intelligence processes take significant labour and time?
- Are there aspects of the intelligence that can be captured by voice, sound, image, or video?
- Are there multiple sensors that can be fused together to provide system level information, with sensors at various frequencies or with different physics?
- Can we eliminate previous methods and replace processes completely with those that leverage the capabilities of AI?
- Is there an advantage to performing AI inferencing at the Edge vs. the Cloud?
- Can we provide in-loop Edge AI based control to improve quality, efficiency, and yield?

**The technical challenges that needs to be overcome by competent Edge AI players are:**

- Real-time performance of the edge inferencing, even on video at 30 fps to enable process control
- Reliable over the air upgrades to algorithms such as neural network parameters
- Reliable machine to machine wireless connectivity in a plant environment leveraging 5G or equivalent
- Low power consumption, especially if the operations are remote and have no access to line power
- Low compute compared to the unlimited processing power on the Cloud, and
- Optimized costs, especially if multiple devices must be deployed for infrastructure such as power grids

**Sample applications will be those that speak the language of the domain:**

- Boiler tube failure reduction in fossil fired power plants using historical data and data fusion at the edge
- Semi-automated operations and maintenance, responding to operating conditions for solar and wind farms
- Visual defect inspection using in-line cameras leveraging super resolution at steel plants
- Thickness measurement and closed loop control for process improvements in lumber manufacturing
- Quality improvements for whiskey production using proxies for smell and taste measurements at the edge, and
- Quality and yield improvement of cosmetic

products, amongst others

**For IIoT to succeed and provide value, local inferencing closest to where the decisions are implemented is critical.** This requires IIoT companies to speak the domain language, articulate plant improvements, and obviate the need for data and decisions to travel between departments for inferencing. For algorithm development and training of the neural networks, the data can leverage the cloud and GPU infrastructure as well as the data scientists and the IT personnel at the headquarters. The algorithms need to be developed with an Edge-native mindset using techniques such as quantized training to be able to inference at the Edge. Most importantly, the CEO or the division head of the application industry must be the driver of the Edge AI IIoT strategy envisioning disruptive targets, breaking down organizational barriers, and enabling a comprehensive data strategy.

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# Wave of Simulation-led Design Exploration

## Generative design

**Ramesh Shankar**, Program Manager, Autodesk

*Background Image Source* Autodesk

The linear product development process has been time-consuming, iterative, and results in a fixed product cost for decades. Industrial designers gather information about customers' needs before developing a few design concepts and experimenting with various forms and materials. The proposed designs are then put to the test, both virtually and physically, to see how well they hold up under various conditions. The design team tinkers with the concepts until they find one that meets the requirements.

Design exploration is limited in traditional product development. Linear design exploration results in more design changes and a longer time from design to production, which has an impact on the overall customer experience. The design cycle results in fixed product costs. Multiple validations and evaluations cause a delay in time to market, resulting in higher product lifecycle costs. As the number of simulations in the iteration phase grows, the way we design with manufacturing constraints takes on new dimensions.

The wave of simulation-led innovation plays a significant role in exploring the design space rapidly.  Each iteration of generative design results in a simulation of a new design with given constraints. Design objectives and goals are entered into the tool by the industrial designer. Design constraints in the space, such as obstacle offset and starting shape, must be specified. Multiple load cases supporting the goal are specified for various simulation studies. Multiple load cases are colour coded, for example, the preservative geometry is green, and the obstacle geometry is red. The designer should give a design envelope to a grow-zone to limit the form size and keep the algorithm from taking too much creative form. The simulations are then uploaded to the cloud, where they can independently explore the solution space. It is producing hundreds of design options in a variety of materials, all of which meet the designers' objectives. The design outcomes are extremely creative and would never have occurred to the designer. Industrial designers, despite their intelligence, could not have designed and simulated hundreds of optimised solutions while considering manufacturing constraints. It's as if you have an infinite number of cross-functional design teams with which to try out different solutions to the same problem. They work concurrently and fast meaning algorithms running on the infinitely scalable supply of CPUs in the cloud. Algorithms that augment natural human capacity & intelligence.

Artificial intelligence and machine learning are

**Figure 1: Traditional Product Development Process**

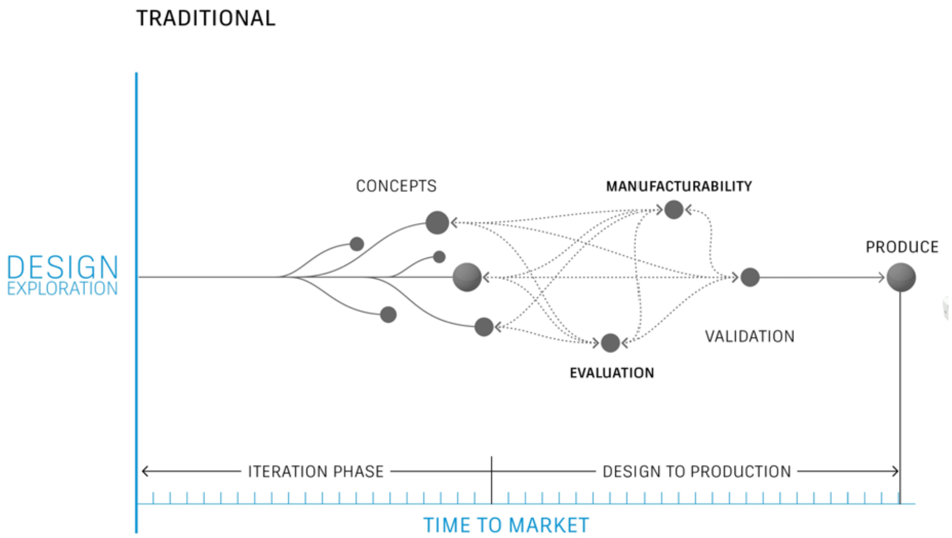
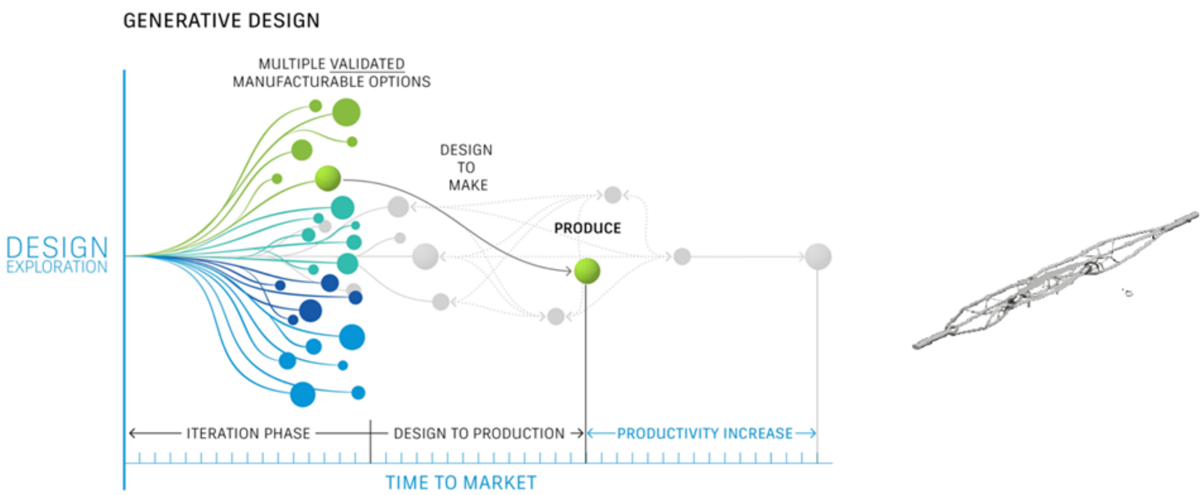


**Figure 2: Design Exploration with Generative Design**




used in generative design to transform ideas into complex design solutions. By generating and exploring hundreds or thousands of higher-performing options based on functional and manufacturing requirements, these new multiple validated outcomes bring new products to market. The benefits of generative design include Additive & subtractive along with traditional manufacturing technologies like 2-axis cutting and 2.5-, 3-, and 5-axis computer numerical control (CNC), Die casting.

## The Benefits of Simulation Led Design Exploration

Simulation-led design exploration begins with exploring the new design objectives in order to solve specific design conundrums "light-weighting" an existing product. There are a number of significant benefits to the approach of increasing creativity and customer focus. The designer's role shifts from that of a CAD jockey to that of a curator and empathizer. It is enhancing the design-to-manufacturing relationship. Designers may create a product with little regard for how it will be manufactured and then throw multiple validated design options at it. It continues until they find some common grounds. With generative design tools, manufacturing intelligence is built into the design process from the start, with considerations for how the geometric variances in a design will change the ability to injection mold, machine, or 3-D print it.

Other business functions should be brought into the fold. Designers and engineers use generative design tools, but they can also benefit other areas of the business in addition to product development, establishing and reimagining manufacturing systems. In the future, manufacturers may extend the functionality of generative design tools to help them design or redesign their manufacturing tools, factories, or supply chains. This new approach can help company owners to come up with a range of scenarios for how to create a certain part, where to locate the factory, and how to supply it. It is also predicting the consumer experience of everyday products which could be a multidiscipline problem requiring contributions from mechanical, chemical, biological, and other scientific domains. These interactions are multi-scale ranging from the chemical bonds that determine interface behavior and material structure to the large-scale manufacturing systems used to produce products around the world with collaborative product development. ith the democratisation of a New Wave of Simulation Led Design Exploration technology, we are on the verge of a paradigm shift in how products are designed, where smart and best algorithms are used to bring multiple validated design options. Each converged design goes through series of simulations to get the optimized solution in the Design Exploration space. Here Industrial Designers might dedicate their creative focus to what they are building rather than how. This generative design technology, which enables simulation-led designs by combining the knowledge and skills of industrial designers and analysts with smart algorithms.

The simulation-led design exploration tool called generative design in Fusion 360 can be used as part of a design exploration strategy for industrial designers, expediting the process from conceptual development to product development, helping to make decisions on the design strategy and aesthetic directions of a product.

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# Hydrogen
# An alternative fuel

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*Background Image Source* akitada31 from Pixabay

## Introduction

Hydrogen (H2) has been conceptualized as an environment friendly alternative fuel as on combustion, it produces innocuous water. Hydrogen can be obtained from a variety of resources such as natural gas, naphtha and coal. While water on electrolysis can also produce hydrogen, using electricity generated from fossil fuels for electrolysis may not be cost effective or benign to the environment. But electricity generated by renewable energy can pose a possible solution. Hydrogen can be used in cars, in houses, for portable power and in several other applications. As an energy carrier, hydrogen can be stored, transported and utilized for energy generation.

Hydrogen is abundantly available in nature and it is estimated that 90% of the visible universe is composed of hydrogen. The mankind was producing and using hydrogen for years before it was recognised as a distinct element by Henry Cavendish in 1766 CE. As hydrogen has been used in bulk for large-scale production of fertilizers etc., good experience has been gathered in managing large volumes of hydrogen. Hydrogen can effectively help decarbonise industrial processes and economic sectors, where reducing carbon emissions is both urgent and quite difficult to achieve. Fertilisers, oil-refining, heavy industry like steel and heavy-duty transportation sector are some of the likely sectors that likely will benefit from hydrogen for decarbonisation.

Hydrogen use today is dominated by industry, namely, oil refining, production of ammonia, methanol and steel. Virtually the entire hydrogen required for such manufacturing operations is supplied using fossil fuels, so there is significant scope for emissions reductions from clean hydrogen. As the usage of low-carbon fuels is quite limited for shipping and aviation, those sectors promise good potential for hydrogen as the fuel. In buildings, hydrogen could be blended into existing natural gas networks, with the highest potential in multifamily and commercial buildings, particularly in dense cities, only hydrogen can be used for boilers and fuel cells. Hydrogen, when produced by electrolysis by renewable energy, can be an effective energy storage. The gas turbines can also operate using hydrogen and ammonia. Ammonia also finds good usage in thermal power plants towards mitigation of carbon emission.

Hydrogen powering the fuel cells for the Fuel Cell Electric Vehicles (FCEVs) causes zero emission from the vehicles. Indigenous production of hydrogen along with the fast filling time and high fuel cell efficiency all contribute to making it an attractive fuel option. A hybrid car run by a fuel cell and an electric motor has achieved efficiency two or more times that of a gasoline engine. Hydrogen can also be used as the fuel for internal combustion engines, which result in tailpipe emissions and demonstrate lower efficiencies compared to FCEVs. The competitiveness of hydrogen fuel cell cars depends on the cost of fuel cells and refuelling stations while for trucks the challenge remains in reducing the delivered price of hydrogen.

The energy demand for automobile and other industrial sectors continues to increase worldwide and such growing need for clean and reliable energy cannot be fulfilled by the conventional fossil fuels. Many countries are now exploring effective alternatives to fossil fuels, including the use of hydrogen. Hydrogen has now emerged as a multi-sector solution globally. The number of countries that directly support investment in hydrogen technologies is increasing along with the number of their target sectors. Over the past few years, global spending on hydrogen energy research and development has risen. Hence, demystifying hydrogen as next viable fuel has become the latest buzz for the world.

The energy content in 2.2 pounds (1 kilogram) of hydrogen gas is about the same as that in 1 gallon (6.2 pounds, 2.8 kilograms) of gasoline. As hydrogen has a low volumetric energy density, it is stored on-board a vehicle as a compressed gas to achieve the driving range of conventional vehicles. The current practices include on-board storage of hydrogen pressurised at 5,000-10,000 psi. For hydrogen storage, the technologies being explored encompass chemically bonding hydrogen with a metal hydride or using low temperature adsorbents.

An important area, which requires close attention in the hydrogen applications is the detection of explosive conditions which is critical for both safety and economic reasons. While hydrogen has an excellent safety record as compared to the transportation and storage of other fuels, there is a need for real-time response on cost-effective sensor technologies. The sensors are required to detect with selectivity, sensitivity, stability and resistance to chemical degradation. Most of the available sensor technologies cover four main categories namely catalytic combustion, thermal conductivity detectors, electrochemical and semi-conducting oxide sensors. These sensors work on the principle of interaction of hydrogen with palladium (Pd).

There is a need for the development of new sensors for vehicle applications with capabilities beyond commercially available systems. Technologies such as micro-machining and micro-fabrication assume importance to fabricate miniaturized sensors. In addition to these, new techniques that allow control, interrogate each sensor and provide self-calibrating capabilities are required.

Most hydrogen production happens close to where it is consumed or typically at large industrial sites. The infrastructure that is required for the distribution of hydrogen to the nationwide network for the widespread use of fuel cell electric vehicles are still under development.

Reducing the cost of hydrogen to match that of the conventional transportation fuel poses the most significant challenge. Government in partnership with industry is initiating a lot of research and development projects to reduce the cost as well as the environmental impacts of hydrogen production.

## Hydrogen – Process Technology

The hydrogen production plays a critical role for any industrialized society. In 2020, approximately 87 million tons of hydrogen was produced worldwide for oil refining, production of ammonia, methanol and as a fuel in transportation.

As of 2020, it has been noted that the majority of hydrogen globally is produced from the fossil fuels by steam reforming of natural gas, partial oxidation of methane and coal gasification. The other methods of production of hydrogen are electrolysis, renewable liquid reforming and fermentation. There are many other processes that are under development through which hydrogen can be produced such as high-temperature water splitting in which high temperature is generated by solar concentrators that split water to produce hydrogen; photobiological water splitting in which microbes like green algae consume water in the presence of sunlight and produce hydrogen as a by-product and photoelectrochemical water splitting in which photoelectrochemical systems produce hydrogen from water using special semiconductors and solar energy.

Steam reforming of natural gas such as methane is the most widely practiced process to produce hydrogen. In this process, methane reacts with steam at high temperature up to 1,000°C under 3–25 bar pressure in the presence of a catalyst to produce hydrogen. This is an endothermic process as heat is supplied to the process for the reaction to proceed.

Steam-methane reforming reaction: $CH_4 + H_2O$ (+ heat) -> $CO + 3H_2$

Partial oxidation has been another process in which methane and other hydrocarbons react with a limited amount of oxygen in natural gas. With oxygen availability less than the stoichiometric amount, the reaction products contain primarily hydrogen, carbon monoxide, a small amount of carbon dioxide and other compounds. This being an exothermic process produces heat. This process is much faster than steam reforming process and requires a smaller reactor vessel.

The chemical reaction reads as : $CH_4 + ½O_2$ -> $CO + 2H_2$ (+ heat).

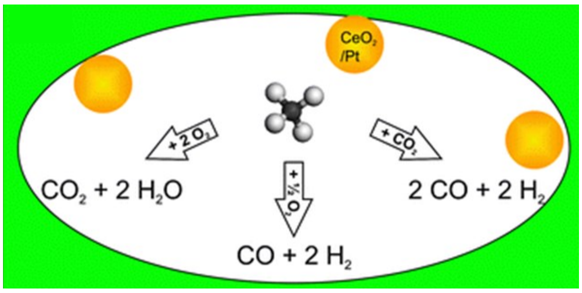



Figure 1 (Source: The Royal Society of Chemistry)

Electrolysis involves ionisation of water into hydrogen and oxygen by passing an electric current. In this process, the resulting hydrogen can be considered as renewable if the electricity

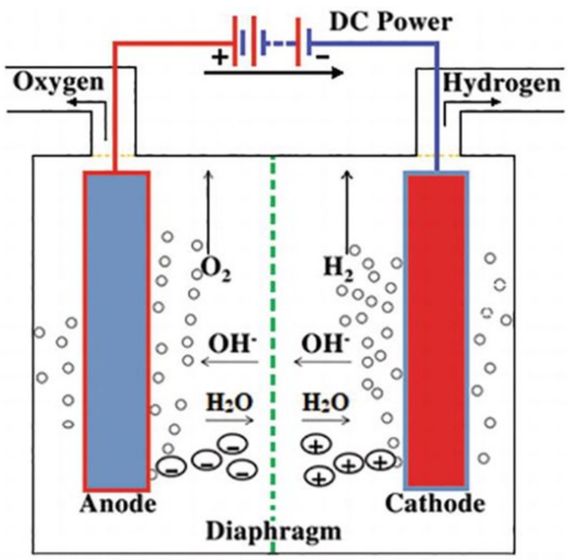



Figure 2 (Source: IntechOpen)

is produced by renewable sources such as solar or wind energy.

Hydrogen can also be produced by the renewable liquid reforming process where renewable liquid fuels (ethanol) is reacted with high-temperature steam to produce hydrogen. In fermentation process, biomass is converted into feedstocks that can be fermented to produce hydrogen.

Numerous thermochemical water-splitting cycles have been investigated for hydrogen production. The splitting process involves high-temperature heat supply between 500°C & 2000°C to drive a series of chemical reactions for producing hydrogen. The chemicals used in this process are reused within each cycle, creating a closed loop that consumes only water to produce hydrogen and oxygen. This is a long-term technology pathway having very low or almost nil greenhouse gas emissions.

The production of hydrogen with the help of algal species under certain conditions is still under development. There exist approximately 3000 different microalgae having potential to produce biofuels as per to U.S. Department of Energy's Aquatic Species Program. Towards replacing fossil fuel-derived energy, photo-biological production of hydrogen is considered to be the most promising technology.

In Photoelectrochemical (PEC) water splitting process, semiconductor materials convert solar energy into chemical energy in the form of hydrogen. The materials used in the photoelectrochemical process are similar to those used in photovoltaic solar electricity generation. While sunlight is used as energy source for the water-splitting process, the semiconductor is immersed in a water-based electrolyte for PEC applications.

## Fuel Cell Technologies

A fuel cell is a device by which electricity is generated through an electrochemical reaction and not combustion. In a fuel cell, hydrogen and oxygen are synthesized to generate electricity, heat and water. **Fuel cells find very good uses today in a variety of applications such as providing power to homes and businesses, hospitals, grocery stores, data centres, vehicles including cars, buses, trucks, forklifts, trains and many more.**

A fuel cell is a combination of an anode, cathode and an electrolyte membrane. Hydrogen and oxygen are passed through anode and cathode of a fuel cell. At the anode site, hydrogen molecules are split by a catalyst into electrons and protons. The protons then pass through the porous electrolyte membrane. As the electrons are forced through a circuit, an electric current and excess heat are generated. The protons, electrons, and oxygen combine at the cathode to produce water molecules. As there are no moving parts involved, fuel cells operate silently with high reliability.

**Fuel cells that use pure hydrogen as fuel are completely carbon-free, with their only by-products being electricity, heat, and water.** Some types of fuel cell systems are capable of using hydrocarbon fuels like natural gas, biogas, methanol, and others. As fuel cells generate electricity through chemistry rather than combustion, they can achieve much higher efficiencies than traditional energy production methods such as steam turbines and internal combustion engines. A fuel cell can be coupled with a combined heat and power system that uses the cell's waste heat for heating or cooling applications towards improving its energy efficiency.

Fuel cells can be scalable that means if individual fuel cells are joined with one another, they can form stacks and these stacks can also be combined into further larger systems. **A few characteristics of fuel cells that make them unique are low-to-zero emissions, high efficiency, reliability, fuel flexibility, energy security, durability and scalability.**

## Hydrogen Economy

Since 1975, the global demand for hydrogen has grown three times and it continues to rise. The major business around the world is now hydrogen supply to industrial users – almost entirely supplied from fossil fuels, with 6% of global natural gas and of global coal going to hydrogen production.

**The countries around the world are betting on hydrogen as a viable renewable energy source. There are 14 countries in the world that are at the forefront of hydrogen innovation. These countries namely, South Korea, Japan, Germany, France, US, UK, Canada, China, Norway, Denmark, Australia, Switzerland, Saudi Arabia and India.**

The international growth of hydrogen infrastructure, trade and technology is creating unique partnerships across nations and continents. There are significant committed investments in green hydrogen world-wide in its production, storage, transportation and dispensing. Major countries such as EU, China, Netherlands, Norway, Portugal, Japan, South Korea, Australia, New Zealand, India etc. are now following stated hydrogen policies.

For example, the 'Hydrogen Strategy' of EU is targeted to decarbonize industry, transport, power generation and buildings. Towards transforming this potential into reality, EU looks at investments, regulation, market creation, research and innovation.

Major firms in transportation sector have committed to carbon neutrality, some of the examples are as follows:

- **European 7 largest truck manufacturers – Daimler, Scania, Man, VOLVO, DAF, IVECO & Ford have signed a pledge to phase out traditional combustion engines by 2040 focusing instead on hydrogen, battery technology & clean fuels.**
- GM to invest over USD27 Billion to be fully

Electric by 2035, VW group to reduce carbon footprint across entire value chain by 30% by 2025 and make CO2 neutral by 2050.

- FedEx to invest USD2 Billion to make its global operation carbon neutral by 2040
- Significant investment in alternate fuels particularly in electrification, hydrogen ecosystem in the transportation sector.
- Saudi Arabia to build a USD5 Billion plant to make green fuel for export
- South Korean Hydrogen Group - SK, Hyundai Motor, POSCO, Hanwha and Hyosung to spend USD38 Billion by end of 2030 in all areas of South Korean hydrogen economy – production, distribution to storage and use.

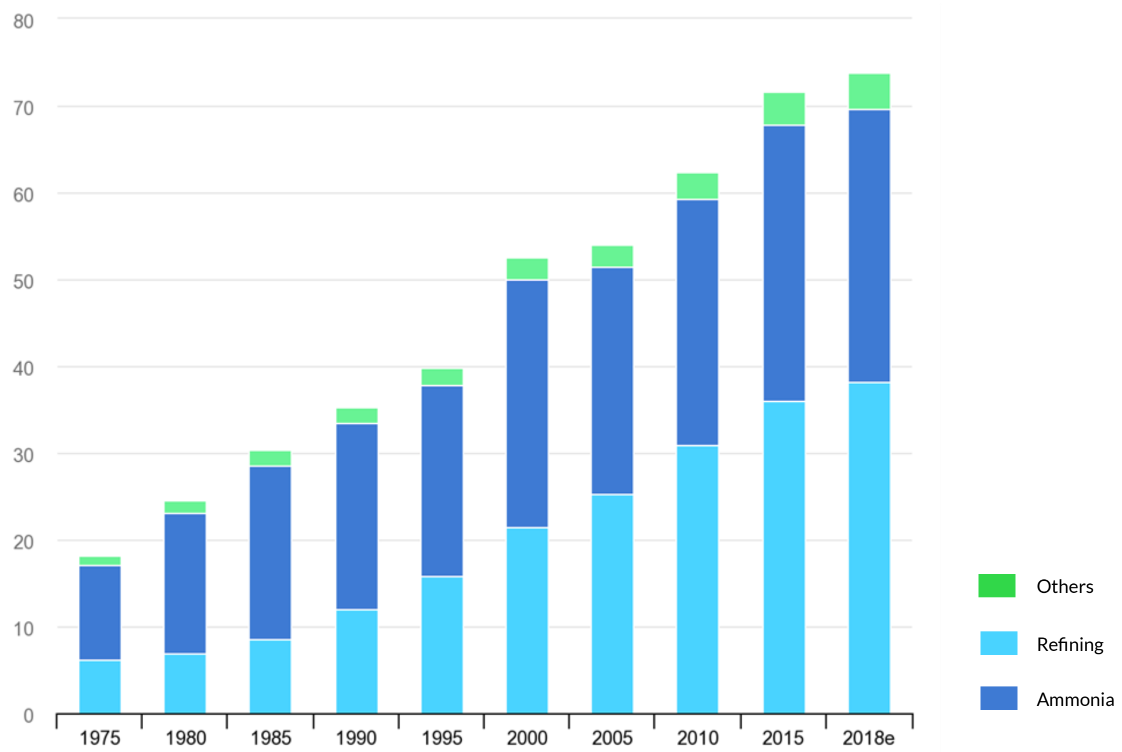
## Way Ahead

Hydrogen has been clearly established as the fuel of the future. While the hydrogen production is not challenging, producing green hydrogen poses serious challenge. India is taking significant steps to lead towards non-fossil fuel based energy sources. Various collaborations have happened in the recent past to achieve the target. Tata Motors in collaboration with the Indian Space Research Organization (ISRO) and Indian Oil (IOCL) had launched a hydrogen fuel cell bus in 2019 in India. National Thermal Power Corporation Limited (NTPC) invited global expressions of interest to provide 10 hydrogen fuel cell buses and cars in Leh and Delhi in February 2020. NTPC plans to utilize renewable energy for hydrogen production and propose to set up hydrogen generation and fuelling stations especially for use in fuel cell vehicles for public transportation.

Hyundai has been planning to launch its first fuel cell NEXO SUV in India by 2021 and proposes to build the required hydrogen infrastructure to support the vehicles near Delhi.

The hydrogen usage will not only help India in achieving the emissions goals, but it will also

**Figure 3: Global Demand for Pure Hydrogen, 1975-2018 (Source IEA)**



reduce dependency on fossil fuels. India's 'National Hydrogen Energy Mission (NHM) 2021-22' has been launched for generating hydrogen from green energy sources. The Mission would focus on the creation of appropriate physical infrastructure and legal framework for hydrogen usage.

The regulations under the National Hydrogen Mission shall have a roadmap for targets and capacity installation. There would be designated hydrogen hubs to attract investments by providing infrastructural support such as renewable electricity, pipelines for production, storage and transportation of green hydrogen. These hubs can be used for logistical convenience to the producers and major users of hydrogen. Department of Science and Technology, Government of India is working on an initiative called 'Hydrogen Valley Platform' to create an integrated hydrogen ecosystem that covers its production, storage, distribution and end-uses.

To enhance the outcome of the National Hydrogen Mission, it is necessary that leading industries from different sectors work in a synergy. India may also consider similar strategies to invest in hydrogen related technologies and infrastructure such as Germany that is already using alliance which aims to set up 400 hydrogen fuelling stations by 2023.

With higher investments in R&D, capacity building and the available demand of clean fuel, India can be uniquely positioned itself as a leading hydrogen economy and by doing so, it can become the most favoured nation for exporting hydrogen to its neighbours and beyond.

Internationally, trading of hydrogen is required if an impact on global energy system is needed. Governments should work to scale up hydrogen in a coordinated way to spur investments that brings down costs and enable the knowledge sharing of best practices. Cooperation among the countries for clean and versatile hydrogen would be is essential.

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Section 2

# INNOVATION SUCCESS STORYBOARD

December 2021, Volume 1, Issue 1

# Solar Innovation makes Clean Drinking Water a Reality in Remote Bengal

Implemented by : **South Asian Forum for Environment**; Funded by : **HSBC**

*Image Source* Hiroki Ogawa from Wikimedia Commons

## SUNVILL WATM: Solar Water-ATM, Sanitation & Hygiene for Sundarbans' Villages

Sundarbans, the rural coastal districts of West Bengal in India, has the largest mangrove in the world and is a biodiversity-rich world heritage site in the Gangetic Delta famous for, among other things, the Royal Bengal Tiger. The area is inhabited by 0.5 million indigenous marginal communities, who are victims of extreme climate events and remain trapped in an energy-water-poverty nexus, consistently ostracized from mainstream development.

## The Challenge

Water is a commodity in salinity infested villages of coastal Sundarbans. In sheer crisis of potable water and sustainable energy, people bought water for drinking. But sanitation remained compromised unhygienic and unsafe for community women. Solar-Powered water-ATM and safe sanitation resolved the twin challenge and paved the path for entrepreneurship.

## The Brief

In resource poor communities of coastal Sundarbans, circular economic intervention with design approach in production and delivery can be a sustainable solution for WASH. This must be engineered through community governance and planning to ensue inclusive growth, while revenue linked paradigm can assure reciprocal community participation and equitable partnership.

## The Plan

A cyclic design for resource amplification by reusing grey water and recycling other disposable effluents and powering the system with 5KVA Solar RO Plant of 500LPH was the core component of the intervention catering 5000 coastal families 24X7 with WHO standard drinking water, 12 bio-sanitations generating 3-CuMt biogas and making bio-manure for organic farming, sustaining a circular economy. Capacities were built in the communities to facilitate technology cooperation and governance thereby augmenting the human resource potential and monitoring was guided by ICT based solutions. Revenues from excess water usages, sales and service charges generated operational costs and as well helped reaching break-evens.

## The Discovery

Sociometry, need assessment and livelihood vulnerability indexing in the project intervention areas led to the significant insights, of which the prime one was the water-energy nexus putting these marginal communities in poverty traps. Equitable access to sustainable energy and healthy waters were denied owing to the highly vulnerable coastal conditions. From perusal of study results it was inferred that community centric cyclic revenue linked designs and value added services can be the fulcrum of the solution. This was followed up with peer reviews, community feedbacks and cost-benefit analysis to arrive at the solution pinnacle.

## The Solution

This WASH intervention caters to ultra-poor vulnerable communities ostracized from mainstream development, who are yet to be assured basic amenities for a dignified life, often being victims of migration, flesh trade, trafficking and as well climate disasters. Innovative cyclic design powered with solar, broke the water-energy nexus for them and provided adaptive low-emission solution in the climate milieu. Creative societal framework ensured equity of access and women empowerment. It provides 'water for life' to all. It is a core intervention of WASH for 'Atmanirbhar Bharat' with sustainable and adaptive blueprint for health & hygiene in this COVID world. It is the first cyclic design in WASH for leveraging circular economic benefits to ultra-poor and as well, designed to restore social dignity of women.

## Designing

As the central tenet of the intervention is a **cyclic design**, it connects the solar powered RO-based water-ATM with bio-sanitation to flush out the refusal water and the sanitation effluents are recycled in bio methanation chambers to generate bio-gas energy. Each of these linkages has an economic efficacy for resource convergence and amplification. Revenues thus generated are managed by women-led social groups to compose the design anthropocentrically. The economic sustainability of the design is pivoted on women entrepreneurial drivers and as well participatory planning that spreads the risks and defines community accountability.

## Delivery

Presently, 18 such sustainable WASH models installed pan eastern India, since 2014, are effectively operating with community governance. It has a break even period of 45 months and NPV of 3.7. It's IER is 70%. It is a sustainable and entrepreneurial solution for 25-30 thousand marginal people from communities below poverty line, who are losing food & livelihood security often.

## Looking Back

Water is life and life revolve around several livelihood opportunities in the rural setting. The water-hubs therefore can well be the community hubs for inclusive growth, human resource enrichment, energy markets and also it can face lift the farming practices as well. Today's supply driven solution would therefore become demanding in future incorporating all such opportunities.

Given the vast nature of the challenges related to Water, only a comprehensive approach will help address the issues. For Sunderban, drinking water and health, the two essentials are facing challenges every minute while the common narratives of climate change is also effecting the residents. That is why the work towards providing the fundamental needs of safe water and sanitation to the people rather say victims of climate change, while trying to break the common 'Water-Energy Nexus' is the need of the hour.

## SUNVILL WATM was the winner of the 10th CII Design Excellence Awards 2020 - Design for Social Impact

December 2021, Volume 1, Issue 1

# Innovation in Steel Industry Offers World Class, Targeted and Reliable Solutions

Implemented by : **Tata Steel Limited**

*Image Source* Tata Steel Ltd

## Introduction

Tata Steel Group is among the top global steel companies with an annual crude steel capacity of 341 million tonnes per annum (MTPA). Tata Steel Group ranks 11th in the world in global steel production (FY'19 rankings) with a revenue of 139K1 Crore. Crude steel production stands at 18.21 MnTPA for Tata Steel India (Tata Steel Limited+TSBSL+TSLP), with an EBITDA/turnover of 24.98%1. Tata Steel India can be described as a combination of 3 businesses / industry types – Mining, Iron & Steel and Engineering & Projects because of the scale at which these activities are performed in the company. The diversity in the major activities, coupled with the challenges of a long and integrated value chain, requires a complex balance of handling heterogenous raw materials (7 types) to produce homogenous hot metal to finally meet a variety of customized requirements of customers in the chosen market segments. This has been achieved through focus on quality and breakthrough / continual improvements which has helped create a leadership position in the market place. Further, Tata Steel operates in multiple geographies within India, working closely with a large number of stakeholders. The operating principle continues to be excellence driven and inclusive with a focused commitment towards positively impacting the environment and lives of the communities in its areas of operation.

## The Innovation

One of the important factors of Blast Furnace operations is Hot Metal Temperature (HMT). HMT determines the stable metallurgy of metallic constituents of Hot metal. Homogenous hot metal must be produced with heterogenous raw material chemistry which makes the maintaining of hot metal temperature always challenging. Deviation from the desired HMT results in higher coke consumption reflecting the major cost to the company. A solution for mapping HMT and casting parameters to reduce the coke consumption was looked since inception of blast furnace, therefore it was a 150 year old problem.

Tata Steel approached this challenge by developing a global first hybrid model (thermodynamic first principle + data science) to predict hot metal temperature, thereby reducing its variations in the blast furnace. The model captures all states and regimes of the blast furnace thus eliminating the repeated training of the model. By doing this, Tata Steel was able to reliably predict HMT for the next hot metal tapping and determine the impact delay of input parameters on HMT. The system was able to reduce the monthly standard deviation of HMT at 'I' Blast Furnace to 5 degrees which is close to the world benchmark. The solution has been horizontally deployed to all other blast furnaces of Tata Steel Jamshedpur and Kalinganagar.

### The Approach

There are three major novel components implemented in this project. First, the model is hybridized by incorporating a thermodynamic approach to capture raw material chemistry deviations in real time thereby calculating the sensible heat of hot metal and slag thus eliminating the ill effects of delayed lab results in the model. Second, the parameters contributing to heat input of the furnace have imparted a dynamic delay mechanism towards contribution of heat to HMT, hence capturing more realistic parametric effects. Lastly, the cast -based patterns capture the state behavior of the furnace which depends on the last observed state only to predict the next incoming state of the furnace (leading to improvement in capturing furnace's hearth behaviour).

### Benefits

The solution led to a reduction of temperature variation in Hot Metal resulting in less consumption of coking coal. The total recurring savings achieved is **INR 115 Million** per blast furnace. Since fuel rate gets saved leading to a reduction in carbon foot print which is equivalent to planting more than **4.6 lakhs trees per annum**.

### The Future

To quantify fuel requirement & automatically regulate, turning black box furnace into "Smart Blast Furnace".

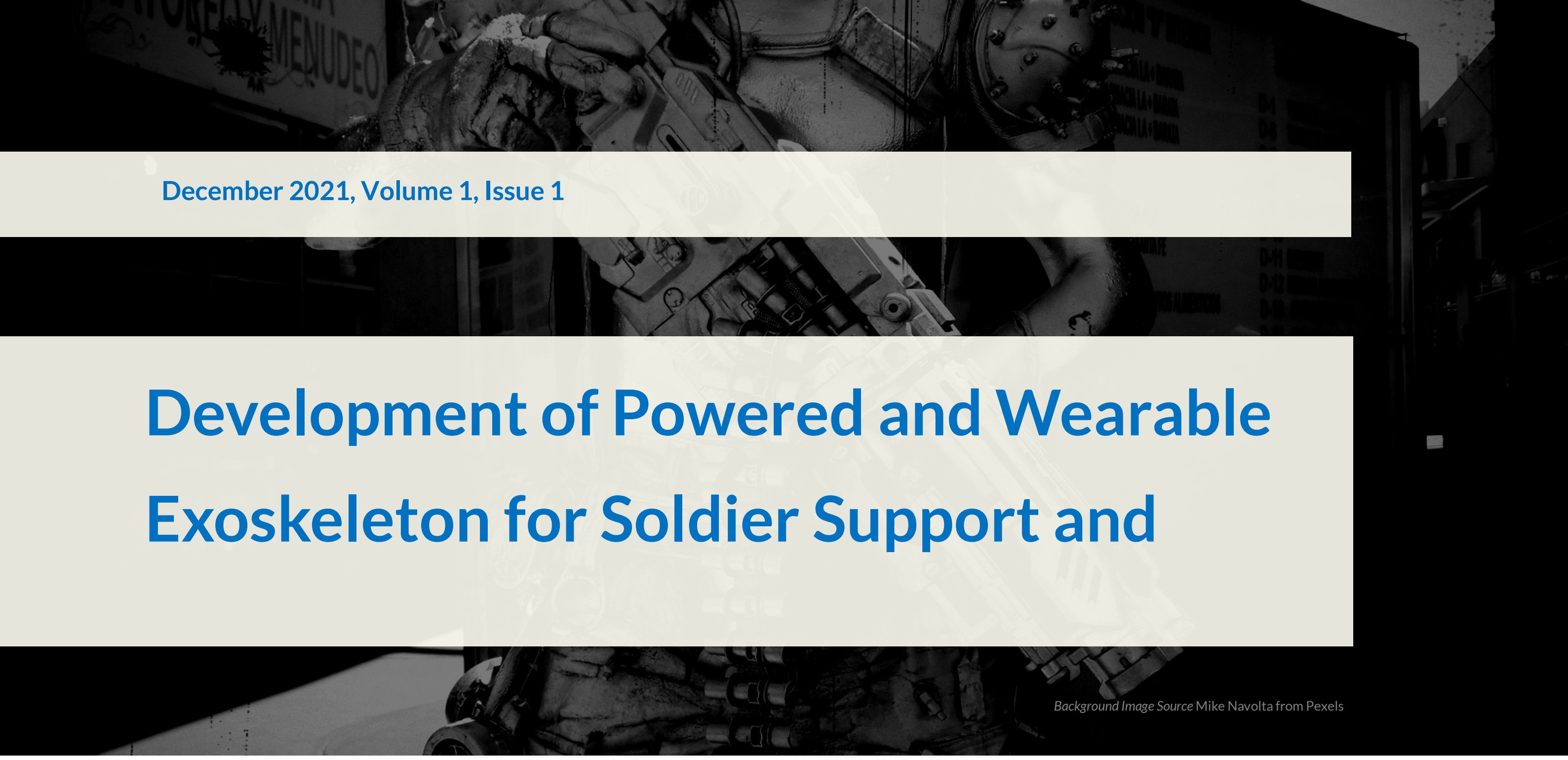
## Tata Steel was the winner of CII Industrial Innovation Awards 2020 - Top 25 Most Innovative Companies

Section 3

# INNOVATION REPOSITORY

December 2021, Volume 1, Issue 1

# Development of Powered and Wearable Exoskeleton for Soldier Support and



*Background Image Source* Mike Navolta from Pexels

## Pretext

A powered Exoskeleton, also known as power armor, exo-frame or exosuit is a mobile machine consisting primarily of an outer framework ( akin to an insect's Exoskeleton) worn by a person, and powered by a system of motors, hydraulics or pneumatics that delivers at least part of the energy for limb movement. The main function of a powered Exoskeleton is to assist the wearer by boosting their strength and endurance. They are commonly designed for military use, to help soldiers carry heavy loads both in and out of combat.

Soldiers in India military have to carry an armory load of around 80-90Kgs for continuous operations, ranging from 6 to 8 hrs. The practical constraints of the human fatigue can put severe limitation on the performance of the soldiers. It is hence important to augment the mechanical working and handling of the armory load by providing it an assistance from a powered exoskeleton. The powered exoskeleton will not only aid the handling of the armory but also improve its performance. Especially because, with the availability of a powered exoskeleton the design of the armory itself can be improvised. Moreover, the idea of such an exoskeleton is not unique, and military personnel of many developed countries like US and NATO are already using these for their soldiers.

## Objective

- Development of a powered & wearable Exoskeleton for robotic augmentation of Military machines working in hazardous applications like mine-field disposal.
- Wearable Exoskeleton for soldier support during combat & battle-field action

## Background

- Need of new-age combat operations for Indian army is a Super soldier – powered by an Exoskeleton to assist by boosting strength and endurance – helping the soldier to handle heavy loads, both in and out of combat.
- The wearable Exoskeleton will also be used to control military machines like Skid Steer loader, deployed in hazardous applications.

### Performance

- Uplift load 80 Kgs for 6-8 hrs. Battery support 5 hrs.
- Operator-less, wearable exoskeleton control of Skid steer loader. Control operation from a distance of 15m.

## Interested Organizations & Applications

- Defence
- Healthcare.
- Atomic Research Centers

## Proposed Project Plan & Key Milestone

| S.No | Activity/Milestone | 1-4 M | 5-8 M | 9-12 M | 13-16 M | 17-20 M | 21-24 M |
|---|---|---|---|---|---|---|---|
| 1 | Kinetics & Kinematics information. Dynamics Simulation | ■ | | | | | |
| 2 | Selection of Potentiometer, Encoder, Electro goniometer, accelerometer, gyroscopes, integrated circuits, material | | ■ | | | | |
| 3 | Control circuit & Controller Architecture development | | ■ | ■ | | | |
| 4 | Integration with a ballistic ammunition and Trials | | | | ■ | | |
| 5 | Motor selection and Exoskeleton design for soldier need | | | | ■ | ■ | |
| 6 | Field trials and Product demo-run | | | | | | ■ |

## Proposed Project team Structure

| | |
|---|---|
| Principal Investigator with responsibility for overall delivery | 1 |
| Advance System Simulations Engineer | 1 |
| E&E Competency - Materials & Sensor Experts | 2 |
| Mechanical design & fabrication Engineer | 2 |
| Controls & Software Engineer | 1 |
| Trial & Testing Engineer | 1 |
| Total | 8 |

- Municipal Corporations

### Sectoral Update

The global exoskeleton market size is expected to gain market growth in the forecast period of 2021 to 2025, with a CAGR of 43.4% in the forecast period of 2021 to 2025 and will be expected to reach USD 1050.4 million by 2025, from USD 248.7 million in 2019. The growth is, for the most part propelled by the growing demand from the healthcare sector and growing investment of the military & defence sector in the exoskeleton.

Experts forecast that the Asia-Pacific Region will witness highest growth during this period as countries like India, invest significantly towards the development and deployment of unmanned systems into the armed forces.

Neuro exoskeleton technologies for soldier locomotion enhancement and increase load carrying capacity has been one of the Thrust Areas of Research for DRDO. Additionally in 2020, under the aegis of AtmaNirbhar Bharat, DRDO released a separate list of 108 systems and subsystems which will be designed and developed exclusively by the Indian industry.

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December 2021, Volume 1, Issue 1

# Teleoperated Robotics for Minimally Invasive Surgical Procedures

Background Image Source Starline from Freepik

## Pretext

The future of healthcare is shaping up in front of our very eyes with advances in digital healthcare technologies, such as robotics. Teleoperated robotics are aiding doctors and medical practitioners while performing surgical procedures have been there in industry for a long time now. However, it is yet to be implemented at large and on a commercially viable scale. The minimal invasive surgery would become a trye reality only once the advances made in the robotics field are well synergized and integrated with the medical procedures.

## Project Objective

- Development of a battery powered, servo controlled, wheel mobile robot, with a 6R-robotic arm mounted on it.
- A dexterous tool for minimally invasive surgical procedure would be mounted on the mobile robot.

## Advantages

- Agility; precision; repeatability;
- Automatic trajectory tracking and no-fly-zone generation;
- Ability to satisfy constraints in position, and speed domains;
- A real-time fusion of multimodal exteroceptive information;
- Automatic recording of gestures made.

## Background

- There is a very high need of precision and real time feedback of the surgical tool position in any minimally invasive surgical procedure
- A high precision mobile robot with a mounted surgical dexterous tool would lead real-time uninterrupted and procedure without any interruptions.

## Interested Organizations & Applications

- Hospitals & Healthcare
- Manufacturers of High precision advance medical equipments

## Application

Dorset is a pioneer in its technology and research and development of architectural hardware, locking solution and furniture and kitchen hardware.

## Sectoral Update

The applications of robotics and automation in healthcare and allied areas will continue to evolve alongside advancements in machine learning, data analytics, computer vision, and other technologies. Robots of all types will

## Proposed Project Plan & Key Milestone

| S.No | Activity/Milestone | 1-4 M | 5-8 M | 9-12 M | 13-16 M | 17-20 M | 21-24 M |
|---|---|---|---|---|---|---|---|
| 1 | Kinetics & Kinematics information. Dynamics Simulation of mobile robot | | | | | | |
| 2 | Design of the dexterous tool tip for minimally invasive surgical procedures | | | | | | |
| 3 | Control circuit & Controller Architecture development | | | | | | |
| 4 | Integration of dexterous tool tip, 6-R robotic arm on the mobile robot | | | | | | |
| 5 | Proto development and lab trials | | | | | | |
| 6 | Field trials and Product demo-run | | | | | | |

## Proposed Project team Structure

| | |
|---|---|
| Principal Investigator with responsibility for overall delivery | 1 |
| Advance System Simulations Engineer | 1 |
| E&E Competency - Materials & Sensor Experts | 2 |
| Mechanical design & fabrication Engineer | 1 |
| Controls & Software Engineer | 1 |
| Trial & Testing Engineer | 1 |
| Total | 7 |

continue to evolve to complete tasks autonomously, efficiently, and accurately. The International Federation of Robots (IFR) predicts an ever-increasing trend in the demand of medical robots within the coming years with an estimation of 9.1 billion USD market by 2022. Experts forecast that medical robots market is expected to reach USD 12.7 billion by 2025 at a CAGR of 16.5% during the period.

Accelerated by the pandemic, technology-led innovations is the future healthcare in India. The Indian Medtech industry, happens to be the fourth largest-medical devices market in Asia and also holds the promise of the highest growth potential among all areas of the healthcare industry, as reported by the Times of India.

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December 2021, Volume 1, Issue 1


# Technology Development Board

## Enabling Technology Development and Commercialization

### About TDB

Industrialization plays a vital role in development of a country and in improving the livelihood of its citizens. India being a country of ideas & innovations, required investments in all sectors of technology for enabling the Indian Industry to commercialize indigenously developed technology and turning them into successful ventures. This required that R&D of Indian Industry is supported and strengthened with suitable financial assistance.

Thus, the Government of India constituted the Technology Development Board (TDB), under the Technology Development Board Act, 1995, as a statutory body under the Department of Science and Technology, to promote development and commercialization of indigenous technology and adaptation of imported technology for wider application, vide Gazette Notification dated September 02, 1996 and October 02, 1996 with following mandate: -

- Provide financial assistance to industrial concerns and other agencies attempting commercial application of indigenous technology or adapting imported technology for wider domestic applications
- Provide financial assistance to such research and development institutions engaged in developing indigenous technology or adaption of imported technology for commercial application, as may be recognized by the Central Government
- Perform such other functions as may be entrusted to it by the Central Government

Since inception, numerous intellectual personalities graced the Board of TDB with their domain specific insights and the same tradition continues till date. The Board constitution of TDB is a blend of representation from senior government officials and Indian industry who provide the vision and direction to the Board in addressing the requirements of the Indian industry.

Prof. V S Ramamurthy was the first Chairman of the Board and Shri. S B Krishanan its first Secretary. TDB had the honor to have legendary missile man of India and Bharat Ratna awardee Late Dr. A P J Abdul Kalam on its first Board.

Some of the illustrious members of the Board from Indian industry since inception of TDB include Shri. Subodh Bhargava, Chairman, M/s. Videsh Sanchar Nigam Limited (VSNL), New Delhi; Dr. Kiran Mazumdar-Shaw, Chairman and

Managing Director, M/s Biocon Limited, Bangalore; Dr.Venu Srinivasan, Chairman & MD, TVS Motors Co. Ltd., Chennai; Dr.Cyrus S. Poonawalla, Chairman & MD, Serum Institute of India Ltd., Pune.

TDB is currently functioning under the leadership of Shri Rajesh Kumar Pathak, Secretary-TDB. Shri Rajesh Kumar Pathak is a 1995 batch IP&TAFS officer with more than 25 years of experience in Administration and Financial Management and has held several prestigious appointments during his long career.

The project evaluation at TDB is a transparent process where an industrial concern seeking financial assistance from TDB is required to submit an application in the prescribed format via @http://e-techcom.tdb.gov.in. Every proposal is evaluated by an Expert Committee comprising of domain Experts from eminent government/academic institutions like IITs, IISc, AIIMS, ICMR, DST, DBT etc and financial experts with over 15 years of experience in project financing.

TDB takes a pro-active role to ensure comprehensive support for technology development and commercialization. It is consistently working towards achieving the goal "to harness & develop commercially competitive technologies for different sectors of the economy through collaborative efforts with the ultimate aim of making India generator and exporter of technologies". This aim enables gearing up Indian industries from "Make in India" to "Self-Reliant India" (Atmanirbhar Bharata Abhiyan).

## Networking with R&D and financial Institutions

To ascertain sustainability in the development, cross weaving between research institutions and enterprises was required to provide stronger pavilion to technology oriented innovative industrial concerns. TDB invested in the reputed venture capital fund and Seed Support for start-ups in incubators. TDB also networked with various reputed international and national agencies.

Since inception, TDB has been financing the innovation ecosystem in the country and has supported a large number of seasoned and first-time entrepreneurs over the years.

## TDB's National Award

In order to appreciate and encourage efforts of industrial concerns TDB, every year, disseminates prestigious National Awards in following three categories, as a part of **Technology Day Celebration**:

- **National Awards for Successful Commercialization of Indigenous Technology:** Cash award worth INR 25 Lakh and a trophy
- **National Awards under MSME category for successful commercialization of a technology-based product**: Cash award worth INR 15 Lakh and a trophy
- **National Awards under Start-up Category:** Cash award worth INR 15 Lakh and a trophy

## Connect:

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Science • Technology • Research • IP • Design • Entrepreneurship

Journal of Technology Leadership and Innovation

# Call for Papers

**CII STRIDE, Journal of Technology Leadership & Innovation**, is a multidisciplinary, peer reviewed periodical that broadcast and present 'unique, original & impactful' technology, design and innovations accomplishments in India, providing the knowledge leadership needed in taking decisive steps towards innovation excellence.

## The Journal will feature papers that have technology leadership perspective oriented with key focus on innovation, design, IP and techno-commercial applications.

**We invite original papers that may engage with (but are not limited to) following themes:**

- Theoretical and conceptual perspectives on current and potential new technologies and design innovations.
- Global and Indian trends, analysis and case studies, in relation to industry best practices, on technology, innovation, design and IP
- The role of technology, design and IP in shaping and realizing entrepreneurial processes and/or strategies. (Business and technical applications).
- The role of technology, design and intellectual property in relation to societal or organizational change, innovation and value creation from a competitive, financial, social or sustainability perspective

## Internal Review Panel

The papers are reviewed by a CII panel of subject experts in the field of technology, design and IPR. The panel members are:

**Mr Soumitra Biswas***, Adviser—Technology and Innovation, Confederation of Indian Industry

**Prof Pradyumna Vyas**, Senior Adviser—Design, Confederation of Indian Industry, Board Member, World Design Organisation (WDO)

**Mr R Saha**, Senior Adviser—Intellectual Property, Confederation of Indian Industry

## Manuscript guidelines and submission information

- Please download the guidelines from the link, or mail your enquiries to stride@cii.in
- Papers are accepted all throughout the year.
- Acceptance / Rejection Notification: Depends upon nature of work and based on reviewer's comment
- Manuscripts submitted to this journal will be considered to be the author's original work and it has not been previously published in any other journal or online forum
- CII STRIDE is an open access publication with a purpose to enhance technology and innovation aspirations of India.

## Mail your papers and enquiries to stride@cii.in

## Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, with over 9000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from 294 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, livelihoods, diversity management, skill development, empowerment of women, and sustainable development, to name a few.

As India marches towards its 75th year of Independence in 2022, CII, with the Theme for 2021-22 as Building India for a New World: Competitiveness, Growth, Sustainability, Technology, rededicates itself to meeting the aspirations of citizens for a morally, economically and technologically advanced country in partnership with the Government, Industry and all stakeholders.

With 62 offices, including 10 Centres of Excellence, in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.


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