35TH VIKRAM SARABHAI MEMORIAL LECTURE

Organised by Vikram A. Sarabhai-AMA Memorial Trust, Ahmedabad

VISION FOR INDIA'S GLOBAL LEADERSHIP

by

Dr. A. SIVATHANU PILLAI

DISTINGUISHED SCIENTIST & CHIEF CONTROLLER (R&D), DRDO

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"Vision for India's Global Leadership"

I am indeed honoured and privileged to deliver the 35th Vikram Sarabhai Memorial Lecture organised by Vikram A. Sarabhai - AMA Memorial Trust, Ahmedabad. Dr. Sarabhai in a short span of time brought the country in the technological path, as he firmly believed that India should be second to none in the use of advanced technologies for the benefit of the society. He strongly advocated that space research will soon uplift the economic standard of the people living in six hundred thousand villages of our country. His vision for the India's Space Programme and his innovative introduction of Satellite Instructional Television Experiment (SITE) transformed the country, the result of which we are seeing today. He spent days and nights in many programmes of our country in Atomic Energy, Space, Industry and also development of research institutions for basic sciences. He was a great architect of India's lead in advanced technologies and their applications. A creator of creative leaders, builder of scientific and management institutions, a role model for visionary leadership, Dr. Sarabhai ever remains with us as one of the gifted sons of India.

I would like to recall one incident which transformed me during the fourth year of my Engineering. It was in January 1968, at the Science Congress at

Madurai, I was demonstrating my project work "time switch" to operate multiple electronic devices, a unique one at that time. Sir CV Raman inaugurated the Exhibition and came first. I explained to him about the project and demonstrated its working. He congratulated me and appreciated as a word of encouragement. Dr. Vikram Sarabhai came very soon following him and listened to me carefully. He hugged me putting his right hand on my shoulder and said, "You are a bright boy and you have a great future". I was thrilled and felt as if I got a boon from God. I completed my final year in 1969 and I kept thinking about a career in Space Technology. What a coincidence! Just before the announcement of my BE results, I saw a full page advertisement of Space Science and Technology Centre (SSTC) recruiting Engineers. I was praying God. I got selected and joined SSTC at Thiruvananthapuram of which Dr. Sarabhai was the Director. On the first day of my joining, he came to Thiruvananthapuram where I met him. My journey started with his Blessings. As a young engineer, I had the opportunity to be chosen by him to work on the evolution of Ten Year Space Profile and on the design project of SLV-3.

I could inherit some of his great qualities of thinking in unconventional way to put the future on fast forward track. He created many leaders like Prof. UR Rao, Dr. Abdul Kalam and many others with whom I have also worked. I could see some of his qualities have entered into many of the leaders, who have helped India to grow in technology and stature. Even today, I could remember those days we spent with Dr. Vikram Sarabhai, remembrance of which remains with me all the time. In memory of the great Visionary Leader who toiled to make India a Nation of importance among the comity of nations in the world, I would like to present to you on the topic "**Vision for India's Global Leadership**".

India's Prosperity Dynamics

Ancient scientists of India were far visionary than others, of that time, in all the fields -mathematics, medicine, aviation, astronomy etc. in terms of scientific

achievements. Astronomer & great mathematician – Aryabhatt; Genius in algebra – was the first to proclaim that the earth is round and rotates on its axis and is acknowledged for calculating Π (Pi) to 3.1416 and Sine table in Trigonometry.

Bhaskaracharya was the first to discover gravity, 500 years before Sir Isaac Newton. Acharya Kanad a founder of Atomic theory – said "Every object of creation is made of atoms which in turn connect with each other to form molecules"; Acharya Susrut; the father of Plastic Surgery performed Rhinoplasty i.e. Restoration of a damaged nose; Acharya Bharadwaj; pioneered in Aviation Technology, Acharya Kapil gave the concept of cosmology and gave the transformation of energy; to name a few. India's glorious past is embedded with a rich scientific and technological heritage from the Vedic age and is an inspiration to create a scientifically advanced and spiritually enlightened human society in which peace, prosperity and happiness together create a heaven on earth. India was one of the oldest centres of pre-historic culture of the world and was the cradle of one of the earliest rich and prosperous civilizations in history. The communities in ancient India were civilized and lived in planned cities with adequate facilities. They built houses of brick, wore cotton clothes and made beautiful gold and silver jewellery, pottery and toys. The Indus Valley civilization and the ruins of Mohenjodaro and Harappa bear testimony to the fact that even as early as 2500 BC, India had skills to develop agriculture, drainage system, well-planned

streets, pottery, tools, jewellery and artefacts. The Harappan culture was the first urban culture to emerge in India. The rise of cities, crafts and trade also furthered the process of cultural unity. Later, the Magadh Empire around sixth century BC saw the birth of cities and use of coins. The first society established in the Indus civilisation became a model for the human race. The prosperity continued during the great Mauryan rule of Chandra Gupta Maurya and later in the third century BC under Emperor Ashoka the Great when India spread its rule far and wide. He unified almost the entire country under one empire but renounced the use of war as state policy. Instead, he declared the victory of righteousness as the real victory. In him, we also find a change in the ideal of kingship. India was aptly called the 'Jewel of the East'. By the time the ancient period of Indian history came to a close, India had developed a culture which was marked by features that have characterized it ever since. During the medieval period, some of the achievements of the ancient times were carried forward and new and magnificent structures were built on those foundations.

Such was the great contribution of India to arts, culture, religious thoughts, science including mathematics, astronomy, cosmology, atomic theory, medicine, yoga and technology including metallurgy, aviation, architecture, township, and also civilisation, spreading to the world.

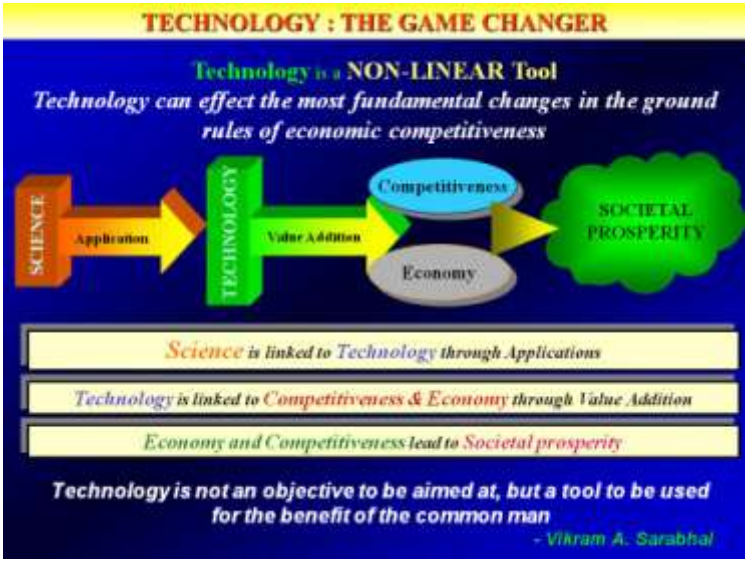
Alas, nearly one thousand years, India's value system and wealth eroded due to continuous invasions by several kings and countries. Along with increased population and non-participation in the industrial revolution, the country slipped down on the economic scale. In the 20th century, Industrial revolution took place in the West and India could not able to take part in this revolution, as India was under the rule of the British, and could not get the benefit of industrialisation. Now, during the information age is India is regaining its pride and in the knowledge age, because of the increased knowledge resources, India's economic prosperity growth and Indians occupying higher level of knowledge position in the world, India will definitely attain the developed status.

Vision for India

The future India where the youth would like to be in should have the following characteristics :

1. A Nation where education with value system is not denied to anyone without any discrimination.
2. A Nation which is the best destination for the most talented scholars, scientists and technologists of the world
3. A Nation where agriculture, industry and service sectors work together in symphony to boost the economy and attract investments
4. A Nation where poverty has been totally eradicated, illiteracy removed and crimes against women and children are absent and none in the society feels alienated
5. A Nation where the rural and urban divide has reduced to a thin line.
6. A Nation where there is an equitable distribution and adequate access to energy, quality water and affordable healthcare
7. A Nation that is prosperous, secure, peaceful and happy with sustainable economic growth rate

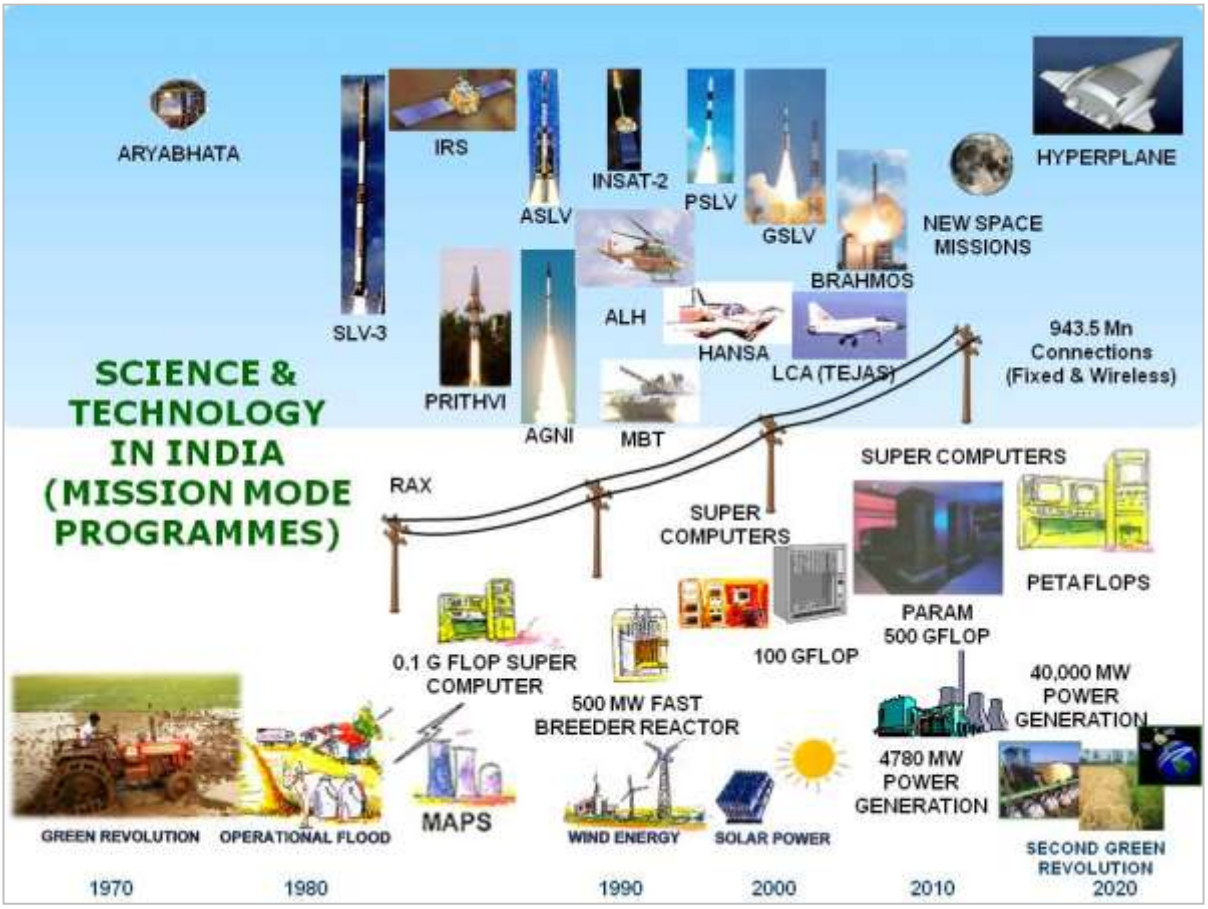
Today, technology is a non-linear tool which can effect the most fundamental changes in the ground rules of economic competitiveness. Science is linked to technology through applications. Technology is linked to competitiveness & economy through value addition which ultimately leads to societal prosperity. Dr. Vikram Sarabhai once said, "Technology is not an objective to be aimed at, but a tool to be used for the benefit of the common man". The benefits of the technology should ultimately result in the growth of mankind.



Science & Technology in India

During the last five decades since independence, India has made all-round technological progress with many accomplishments. The Green Revolution and the Operation Flood have made the country self sufficient in food and the largest producer of milk respectively and are examples of mission mode programmes under the great personalities. India is top ten in the telecommunication network with 943.5 million connections. Advancements in related healthcare technologies have resulted in increase of life expectancy. The quest for tapping natural resources for power generation has given new impetus to the power sector. The nuclear tests in 1974 and in 1998 made India a nuclear weapon state, and India has mastered harnessing this nuclear energy into power generation to meet the growing demand for electricity, with an aim of reaching 40000 MW power generations by 2020. With established strength in computing systems, software and communication and a large pool of talented software specialists, India has emerged a strong nation in the field of information technology. Spectacular achievements came in space missions,

strategic and cruise missiles (Agni, Prithvi and BRAHMOS), aeronautic systems like LCA now called Tejas, IJT, ALH and related aerospace technologies. In 2020, India aims to have new aerospace ventures including moon mission, hyperplane and reusable hypersonic missiles.



Mission Mode Programme

All these could become possible with the great visionary leaders through mission mode programmes.

Agriculture

From a situation of famine and heavy shortage of food in our country, Green Revolution was born in the early 70s by Shri C. Subramaniam, the then Union Minister for Food and Agriculture and supported by Agricultural scientists Dr. M.S. Swaminathan and Nobel Laureate Dr. Norman Borlaugh, using skills in

genetic engineering to establish self-sufficiency in food grain production with political will. The success of the Green Revolution can be estimated by the fact that India today grows more than 241.6 MT of food grain in a year and has the second Green Revolution in place for stepping up to 400 MT in 2020.

Milk

The Dairy Technology has been successful in India with the "White Revolution" conceived by the National Dairy Development Board based at Anand. All this started with the initiative of Dr. Varghese Kurien and inauguration of Kaira District Co-operative Milk Producers Ltd., Anand in Oct. 1955. It started with 64 societies and 20,000 members. Their brand name 'Amul' became a household name. Today, India is the largest producer of milk in the world with 127 million tonnes, through cooperative movement.

Steel Industry

The great industrialist of our country Jamshetji Nusswerwanji Tata envisioned India to manufacture steel. When he wanted to establish a steel industry he needed technology of steel making. So he boarded on a ship and went to London to meet his English friends asking for the technology. He met Swami Vivekananda in the same ship. Swami Vivekananda was travelling to Chicago to give the famous address on Hinduism. JN Tata explained Swamiji about his intention. Swamiji told him "When you are trying to make a steel industry, think of building an institution which will teach material science". JN Tata agreed to the suggestion and got down at London to meet his friends, whom he expected the help, told that if, India makes steel we will eat them. Offended by their statement and refusal of steel technology, he then proceeded to USA to meet some friends, who helped him later. At that point JN Tata remembered Swamiji's word and established the Indian Institute of Science at Bangalore with a focus on metallurgy and material science. The Indian Institute of Science opened in 1911 in Bangalore, many years after his death. His vision was fulfilled. Visionary may die, but the vision never dies. Today, the Tata

family has purchased the steel industry CORUS from UK, which once refused technology to him.

Nuclear

Dr. HJ Bhabha built TIFR and BARC to undertake research in nuclear energy to make the nation strong and to develop and utilize for applications such as for power generation, food eradication, water management and medicine. The present capacity for power generation is about 4780 MW. As raw material availability is being ensured, it is time that India has a vision for nuclear energy by realizing 40,000 MW of power by 2020. This will provide an opportunity for future industrial growth and better quality of life and more agricultural productivity.

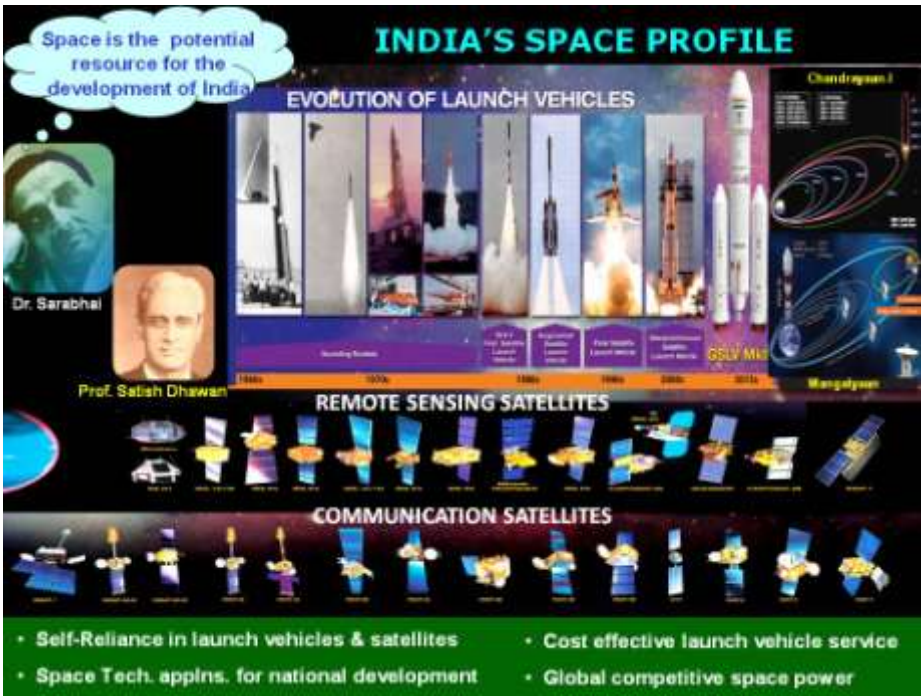
Space

Dr. Vikram Sarabhai pioneered the India's Space Programme. Dr. Bhabha supported Dr. Sarabhai in setting up of the first rocket launching station Thumba Equatorial Rocket Launching Station (TERLS) at Thumba, primarily because of its proximity to the equator. The successful inaugural flight of Nike Apache took off on November 21, 1963 with a Sodium Vapour Payload. The TERLS was dedicated to the world on February 2nd, 1968 by the then Prime Minister Smt. Indira Gandhi. Family of Sounding rockets including Rohini rockets were developed which were used regularly in conducting experiments related to meteorology, aeronomy, X-ray, astronomy, and so on. Dr. Sarabhai's

initiative of having joint experimental satellite project was resulted in the commencement of Satellite Instructional Television Experiment (SITE) with a series of innovative and constructive educational television programmes for national development and for educating the Indian masses living in remote rural areas. The television programmes were broadcasted through ATS-6 satellite stationed above India covered more than 2400 villages in six Indian states and territories. The SITE educational programmes helped the children to learn, community living and improve their basic concepts and skills in the areas of numeracy, language and Science.

The evolution of Ten Year Space Profile gave the directions for the realisation of future launch vehicles. This development furthered the indigenous capability for satellite launching from low-orbiting to synchronous levels. The successful

launches of PSLV established capacity to lift 1200kg of satellites to an 800km polar orbit. Further developments led to the launch of GSLV (Geosynchronous Satellite Launch Vehicle) for putting a payload capacity of 2500 kg class satellites in geosynchronous transfer orbit. The Indian Remote Sensing (IRS) series of satellites greatly helped in remote sensing including ocean resources survey and high-resolution mapping. With PSLV & GSLV operational, India has established not only self reliance with launch and satellite capability but also offering cost effective launch service to different countries. The successful launch of PSLV and the Indian satellite CHANDRAYAAN-I orbiting around the moon shows our mastering in space technology. Now we are entering into Mars mission and manned mission. A new era has begun. Space Technology has changed the life of a common man. The space applications programme using the Indian remote sensing and communication satellites have continued to expand in the coming years. We see today that Sarabhai's vision has been fulfilled and India has become a space power. Space applications have become part of our life.



Space Technology Applications

Our satellite based communication and remote sensing technologies have provided services related to education, healthcare, weather prediction, land and water resources management, mitigation of impact of natural disasters, etc.

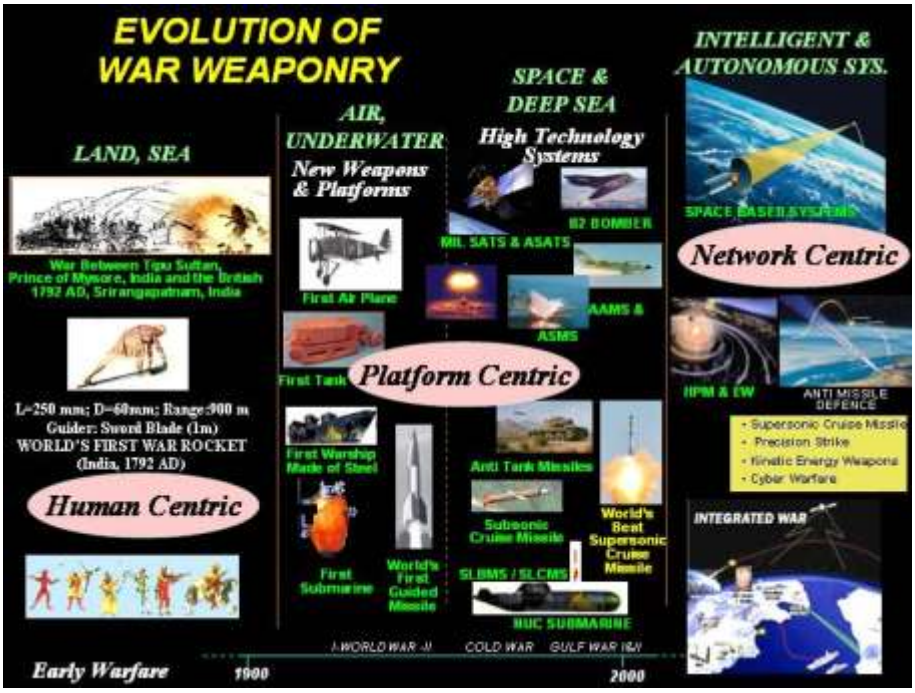
The Indian Remote Sensing (IRS) series of satellites have greatly helped in

remote sensing including ocean resources survey and high-resolution mapping. Around 473 numbers of Village Resource Centres (VRC) which provides spatial information along with collateral information and services like telemedicine and tele-education. Using the services of INSAT, population in remote and rural areas have been benefited through Telemedicine network of 389 Hospitals – 311 remote; 60 superspeciality & 18 mobile clinics. To enhance the Tele-education activities, 83 Networks, 56164 classrooms have been connected through EDUSAT network. The moon mission will help in exploring the helium-3, the new source of energy, available in abundance at moon.

Evolution of War Weaponry

The first 'ballistic weapons' probably were rocks that caveman hurled at each other. These 'missiles' were followed by sticks fitted with pointed stone heads to make spears and later by wood and 'string' devices that propelled smaller wooden shafts through the air. In the 18th century, an interesting innovation happened in India in using, first time, a war rocket. Tipu Sultan used the world's first war rocket in the Srirangapatna war in 1792, launched in huge numbers against the British cavalry. Tipu's rockets of that period were much more advanced than any known weapon used in the war. The rocket consisted

of a tube of 60 mm dia and 250 mm long with 2 kg gun powder, fastened to a sword which can reach to a range of 1.0 to 1.5 km. The metal cylinder used was made of hammered soft iron. The use of iron increased bursting pressure which permitted the propellant to be packed to greater densities thus giving the rocket a higher thrust and range. The rocket is now displayed at Woolwich Artillery Museum in London. Moreover, Tipu had trained rocketeers as a special force.



War weaponry has gone through various phases of development, particularly during 20th century with new weapons and platforms. The most significant developments were the V2 rocket – the first guided missile developed by the Germans in the Second World War and Tomahawk cruise missile of USA used in the Gulf war. In the 21st century, BrahMos, a missile which is versatile and capable of multi-role, multi-target and multiple missions, has emerged. From the world's first rocket in 1792, India travelled to come again in 2001 with BRAHMOS, the world leader of cruise missile family. From human warfare, we have come a long way to intelligent and autonomous systems with faster operations capable to utilise deep sea and space networked with sensors and weapons.

Missiles

India's missile programme, IGMDP was led by Dr. APJ Abdul Kalam with his vision of making India a strong & self-reliant country. In the IGMDP, India has made Prithvi and Agni operational as strategic missile systems. We overcame the technology denials and the technology gap with new approaches, concepts and methods to make a leap-frog. Many innovations had been introduced in the realisation of critical missile technologies such as supercomputing, computational fluid dynamics, re-entry structures with carbon composites, phase shifters required for multifunction radars for multiple missiles tracking and guidance, high accuracy sensors with embedded software, high energy propellants, underwater systems, Electronic Warfare systems, multifunction radars, cryptology and many others. Self-reliance in critical technologies placed our country close to the developed nations.

Technology to Society

The Indian missile programme has given important spin off technologies, particularly for healthcare at affordable cost. One among them is Floor Reaction Orthosis (FRO). FRO is the modern remedy for the polio patients whose quadriceps muscles are paralyzed. Compared to conventional 3 kg caliper, FRO weighs only 300 gm and costs half. There was a necessity for standardization, process upgradation and productionisation of FRO with due clinical validation in order to cater the

pressing need of the large number of children affected by polio. Today more than 42000 of such children have been fitted with the FROs. The introduction of indigenous stents made from the material used in missile projects, helped to bring down the cost to a one fifth of its original cost. Anamica a medical 3-D visualisation software enables the doctors to simulate the surgery on their computers. Aspheric magnifier is useful for improving the vision of the visually impaired. An ophthalmic laser (Nd-Yag) photo disruptor known as Drishti-1064 developed at 1/3rd cost compared to imported one, is used for capsulotomy and iridotomy. The new treatment modality to use 2 Deoxy-D Glucose as a radio sensitizer for cancer therapy has also been developed. Sanjeevani, an acoustic detector from sonar technology, is a lifesaver in natural calamities such as earthquakes, avalanches, etc. This has been used to save the lives of people buried under debris during earthquake in Gujarat.

BrahMos Supersonic Cruise Missile – The Brahmastra

The Gulf Wars in 1991 gave us the message that cruise missiles are very important to destroy the enemies' assets on the first day of the war, without even the enemy knowing. Cruise missiles are stealthy, fly at very low altitude and very precise to hit the target. American Tomahawk missiles were dominant during the Gulf Wars, but it has a subsonic speed. India decided to go for cruise missile development, with a difference. When the whole world was using subsonic (i.e. speed less than that of sound) cruise missiles, India decided to go for

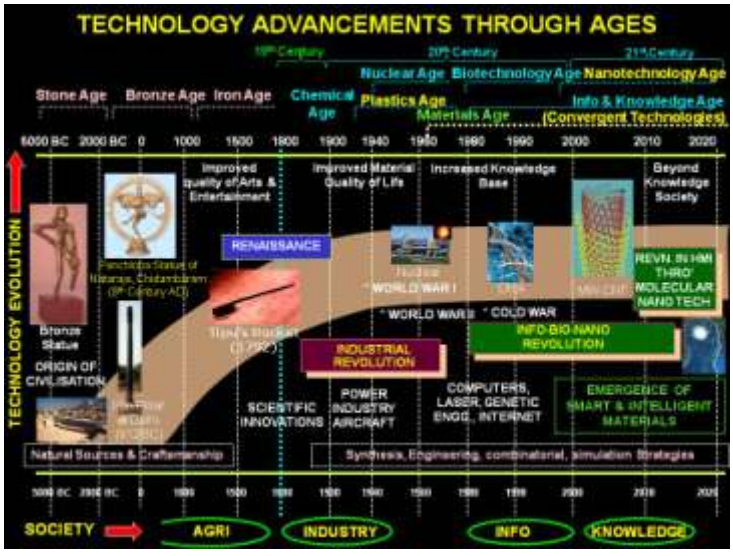
supersonic cruise missile, **3 times faster than the sound**. To cut short the time of development and inherit very high level of technology, India joined hands with Russia making the BrahMos joint venture. BrahMos is responsible to design, develop, produce and market a world class cruise missile. A new generation young scientists from the Indian academic institutions with the help of experienced Russian specialists, formed a consortium with industries of India and Russia, made it possible to create a wonderful product, i.e. BRAHMOS. It is a supersonic cruise missile, which can be launched from multiple platforms on land, on sea, underwater and in air with multiple missions against land and sea targets. The unique nature of BrahMos with its universality made Indian Armed Forces, the first in the world to possess supersonic cruise missiles. Various versions of BRAHMOS have been developed, produced and inducted in the Indian Armed Forces on ships and on land. BrahMos is a world leader in the cruise missile family. The developed world got astonished to see the Indian might through this **Brahmastra**. We together established that "**We can do it**". Today, there is no competitor to BRAHMOS in the world and many countries want to have BrahMos system in their armoury. Thus, BrahMos has established a global leadership for India. To achieve this unique position what needed are dynamic leadership, creative thinking and innovative approach using technology as the tool.

Hypersonic Reusable Cruise Missile–The Sudharshan Chakra

Lord Krishna took Viswaroop at Kurukshetra, with his mighty ever-moving Sudharshan Chakra on his right index finger. The importance of Sudharshan Chakra was its ever readiness to destroy the enemy and come back. If this is so, the idea came to us that why not we create a hypersonic cruise missile which destroys the target and flies back to us for re-use. Going at a speed of Mach 7, deliver the warhead, assess the destruction of the target, come back and get ready to go again, i.e. Hypersonic Reusable Cruise Missile, the next version of Sudharshan Chakra. This is the BrahMos-II programme and it has been started with its design and basic technology development.

Technology through Ages

During the last 5000 years, unique cultures have come into existence as the man continuously attempted to have better life for himself and the society around him. Technology, over the years, played a very dominant role right from the Stone Age to the industrial revolution and information & knowledge age of today, with different manifestations. We are, today, at the convergence of information with bio and nanotechnologies and the future belongs to the nanotechnology age.



Convergence of Nano-Bio-Info Technologies

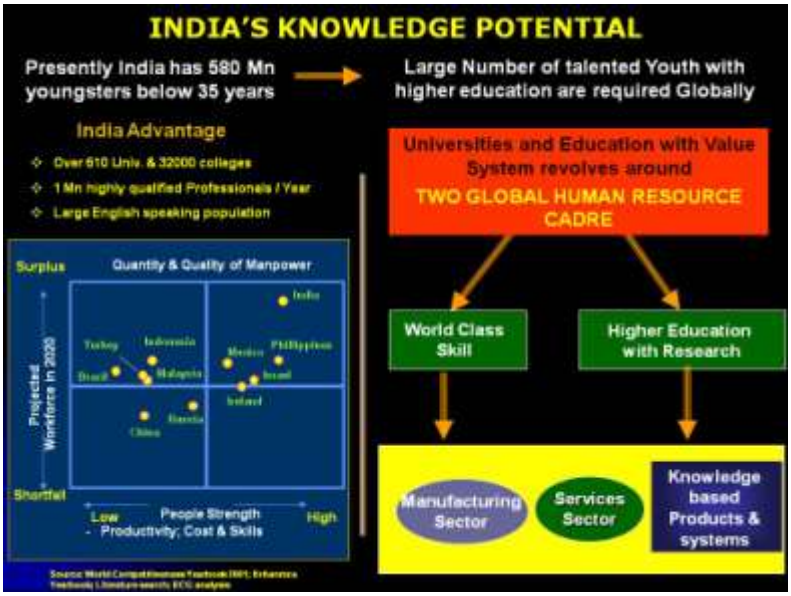
The information technology and communication technology have already converged leading to Information and Communication Technology (ICT). Information Technology combined with bio-technology has led to bio-informatics. When Nano technology and ICT meet, integrated silicon electronics, photonics are born and with biotechnology linked, a new science called "**Intelligent Bioscience**" will be born which would lead to a disease free, happy and more intelligent human habitat with longevity and high human capabilities. This convergent technology can lead to the development of nano robots. Nano robots when they are injected into a patient will diagnose and deliver the treatment exclusively in the affected area and then the nano-robot gets digested as it is a DNA based product.

Futuristic Dominant Technologies

The technologies without any doubt are going to play a major role in the years to come. The futuristic dominant technologies that are going to revolutionise any nation are Nano-Bio-Info Technologies and their Convergence, Robotics and Artificial Intelligence, Advanced Sensors, Smart and Energetic Materials, Green Technologies, Nuclear Fusion Technology, Geo-spatial Technologies, Technologies for Low Cost Access to Space and Mining in Planets and Hypersonic Technologies. The skilled human resources with a hold on futuristic technology will pave way for the competitive product.

India's Knowledge Potential

At present India has five hundred and eighty million youth which will continuously be growing till the year 2050. This most valuable resource of our country needs to be nurtured. In the 21st century, India has plans to empower the talented youth with higher education for the task of knowledge acquisition, knowledge imparting, knowledge creation and knowledge sharing. Keeping this in mind, our Universities and educational systems will be creating two cadres of personnel: (1) a global cadre of skilled youth with specific knowledge of special skills (2) another global cadre of youth with higher education. These two cadres will be utilized not only for powering the manufacturing and services sector of India but also will be made available for fulfilling the human resource requirements of various countries. All Indian youth will be with either a world class higher education or with world class skills sets. This will become base for world level required for knowledge based products and systems development.



Developed India

India has to aptly exploit its bountiful resources, knowledge base and nurture the growth of advanced technologies to become a developed nation in the next ten years. Technology and knowledge are the two factors which add value to any product. The core strengths will lead to the desired goal through mission projects, the success of which will make India a strong and self-reliant country. India today is in a unique position in the world attracting all developed

countries to look at it because India is the best resource hub of young intelligent minds. The history of India dominating during the civilizational age is coming back when the society has moved from agriculture to knowledge. This is a point of greatest advantage for all of us and it provides an opportunity for India to become an economic power and attain Developed India status and will regain its greatness.

Creative Leadership

To keep the aspects of 21st century in mind, the Youth of our nation is to evolve a learning process to meet the demands of the knowledge society. For that creative leadership is required. We need young leaders who can command the change for transformation of India into a developed nation embedded with knowledge society from now to twenty years. The leaders are the creators of new organizations of excellence.

The connectivity between missions of developed India, economic prosperity, technology, production, productivity, employee role and management quality, all linked to the creative leader. Who is that creative leader? What are the qualities

of a creative leader? The creative leadership is exercising the task to change the traditional role from commander to coach, manager to mentor, from director to delegator and from one who demands respect to one who facilitates self respect. The higher the proportion of creative leaders in a nation, the higher the potential of success of visions like "developed India."

Dr. Vikram Sarabhai always thought of the Nation greater than himself. He was a leader with a great vision. He always had the passion to realize the vision he has dreamt of. Sarabhai always had the curiosity to travel into an unexplored path with honesty of purpose with high level of integrity. At times it has been difficult for him to have the courage to take difficult decisions but he took them as he was capable enough to withstand failures and motivate his team along with himself to overcome from the failures. His nobility and compassion in management has been remarkable. It would be ideal to say that he was a Creative Leader and Creator of Creative Leaders.

Thank you