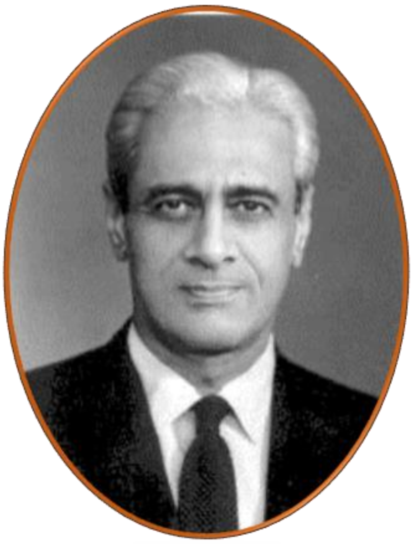


9th Prof. Satish Dhawan Memorial Lecture

VISION FOR INDIA'S GLOBAL LEADERSHIP

BY

Dr. A. SIVATHANU PILLAI

Former Chief Controller (R&D), DRDO
Founder CEO&MD, BrahMos Aerospace
Visiting Professor, Indian Institute of Science

At

Satish Dhawan Space Centre, SHAR

25 September 2014

Prof. Satish Dhawan Memorial Lecture

"Vision for India's Global Leadership"

By

Dr. A. SIVATHANU PILLAI

I am indeed honoured and privileged to deliver Prof. Satish Dhawan Memorial Lecture at this Sriharikota Space Port of India named after him. It is always a great feeling when I think of Prof. Dhawan whom I regard as my Mentor along with Dr. Vikram Sarabhai and Dr. APJ Abdul Kalam. These great Visionary leaders shaped my career displaying high level of competence in the field of Aerospace. I am grateful to them for ever. Like me, there are many Aerospace leaders nurtured by them.

Prof. Satish Dhawan, who became Chairman ISRO in 1972, translated the Space Vision of Dr. Sarabhai into defined missions and goals for attaining self-sufficiency in launch vehicle and spacecraft technologies. The seeding of Prof. Dhawan and his great leadership built ISRO as one among the world's top Space Institutions in a short span of time. Today, India is well recognised as a Space Power and is marching towards exploring the Moon and Mars and will soon have manned space flights. This remarkable achievement in the space journey of India can be wholly attributed to the Visionary Leadership of Prof. Dhawan, inherited by his successors.

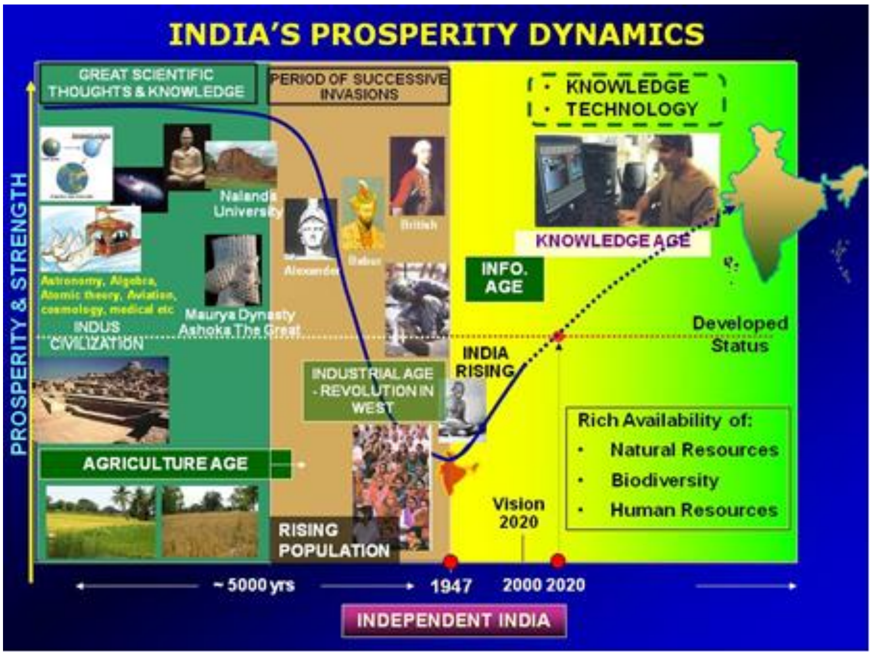
Prof. Dhawan made multidimensional contributions to scientific education, research, policy formulation through Indian Institute of Science as its Director and applications of space technology to solve national problems through the use of science. Both IISc and IRSO are testimony of his scientific thoughts and technology leadership. Prof. Dhawan kept the technology development work open and transparent to the nation's scientific community through an elaborate system of reviews and mission management. In such review meetings, he encouraged young engineers to give suggestions thereby facilitating dissipation of knowledge and ideas. Not only he was a leader in technology management but also is a designer by himself. I recall that I along with Dr. Kalam worked with him at ISRO Hqrs. in 1980-82 in evolving an alternate configuration for PSLV. I had the fortune of getting exposed to high technology skills of Prof. Dhawan, demonstrating him as a designer. He approved this alternate configuration for PSLV which has become the workhorse of ISRO. The sparkling success of PSLV with consistent performance was due to his innovative approach in evolving the mission and configuration with built-in reliability, his encouragement to the industries, elaborate review system and mission management. He gave a roadmap for GSLV, remote sensing and communication satellite programme to bring ISRO to a world class organisation. Prof. Dhawan was a great thinker, analyst, technology leader and institution builder.

Even today, I cherish the memories of those days in 1980s, I spent at ISRO Hqrs. working with Prof. Dhawan, meeting him one to one on every Tuesday and interacting on decision process, and the remembrance of which remains with me all the time. In memory of the great Institution Builder, 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 in 600 BC "Every object of creation is made of atoms which in turn connect with each other to form molecules"; Acharya Susrut (600 BC);

the father of Plastic Surgery performed Rhinoplasty i.e. Restoration of a



damaged nose; Acharya Bharadwaj (800 BC); pioneered in Aviation Technology, Acharya Kapil (3000 BC) 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 before Independence, 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.

Science & Technology in India

During the last five decades since independence, India has made all-round technological progress with many accomplishments. The first Green Revolution in 1970s resulted production of 260 million tonnes on food grains and the second green revolution is poised to produce 400 million tonnes by the year 2020. Operation Flood have made the country self-sufficient in milk production and today, India is the largest producer of milk.

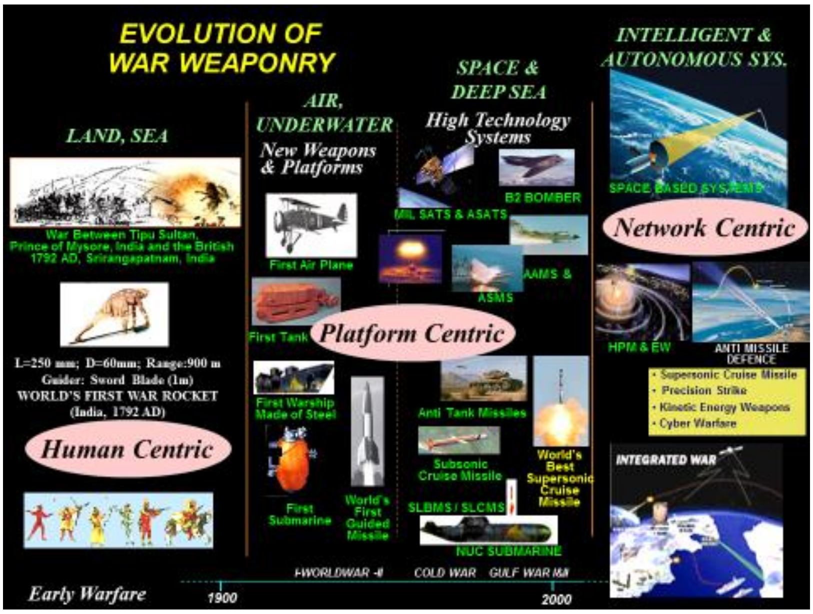
India is top ten in the telecommunication network with 943.5 million connections. Advancements in healthcare technologies have resulted in increase of life expectancy and medical tourism. The quest for tapping natural resources for power generation has given new directions through wind and solar energy. 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 20000 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 and ITES, with a revenue crossing $100 billion. Spectacular achievements came in space missions, strategic and cruise missiles (Agni, Prithvi and BRAHMOS), aeronautic systems like Tejas, IJT, ALH and related aerospace technologies. In the future, India aims to have new aerospace ventures including moon mission, hyperplane and reusable hypersonic missiles.

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

When we were working at ISRO for SLV-3 at Trivandrum, we were also thinking of a missile project called REX (Re-Entry Experiment). Dr. Kalam wanted to convert the SLV-3 into a missile. But Prof. Dhawan wanted to keep ISRO away from missile development as it might affect the international cooperation that ISRO had with many countries. But Dr. Kalam's mind was always revolving around developing a re-entry class of missiles. Indeed he did that, not in ISRO but in DRDO.

In Dr. Kalam's own words regarding REX in his 'Wings of Fire',

"Meanwhile, I carried out an analysis of the application of SLV 3 and its variants with Sivathanu Pillai, and compared the existing launch vehicles of the world for missile applications. We established that the SLV 3 solid rocket systems would meet the national requirements of payload delivery vehicles for short and intermediate ranges (4000 km). We contended that the development of one additional solid booster of 1.8 m diameter with 36 tonnes of propellant along with SLV-3 subsystems would meet the ICBM requirement (above 5500 km for a 1000 kg payload). This proposal was, however, never considered. It nevertheless paved the way for the formulation of the Re-entry Experiment (REX) which, much later on, became Agni".

In ISRO, in spite of SLV-3 success, Dr. Kalam, was facing frictions - some of his bad times. He was thinking of moving to missile development, utilizing the offer of Dr. Raja Ramanna. But Prof. Satish Dhawan did not approve this. Dr. Kalam wrote a hand written letter to Prof. Dhawan expressing, "My heart is on missiles and I want to go." Dr. Raja Ramanna, passed his observations regarding Dr. Kalam to his successor Dr. V.S. Arunachalam, who approached the then Defence Minister Mr. R. Venkataraman and got Dr. Kalam to DRDL from ISRO. A new era in the Indian missile development began.

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. In spite of Missile Technology Control Regimes (MTCR), many innovations had been introduced in the realisation of critical missile technologies through networking of many academic institutions and industries as partners. The national effort led to realization of technologies and systems 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. It proves that "***Technology denied is technology gained.***"

Missile Defence

India today is capable of design and development of any missile system to secure our nation. Now, we have operational Agni versions with nuclear payload having ranges from 700 km to 5000 km; Prithvi with all three services; Akash with Air Force; and Nag in the final evaluation for Army. DRDO has also developed a two layer ballistic missile defence to protect our assets and people from missile threats from outside. IGMDP made India a Strong Country.

BRAHMOS Supersonic Cruise Missile – The Brahmastra

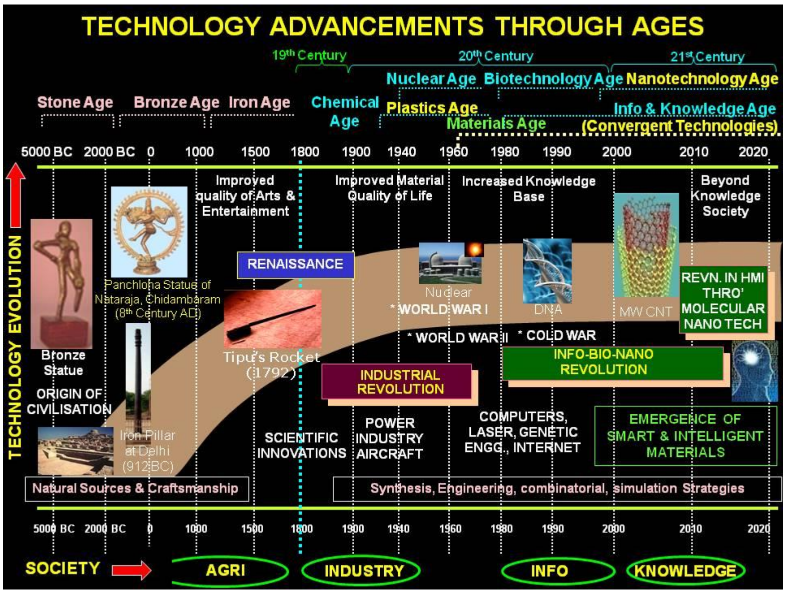
The Gulf Wars in 1991 gave us the message that cruise missiles are very important to destroy the enemies' assets on the first day of the war, without even the enemy knowing. Cruise missiles are stealthy, fly at very low altitude and very precise to hit the target. American Tomahawk missiles were dominant 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**. 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, breaking the sixth country syndrome.

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.

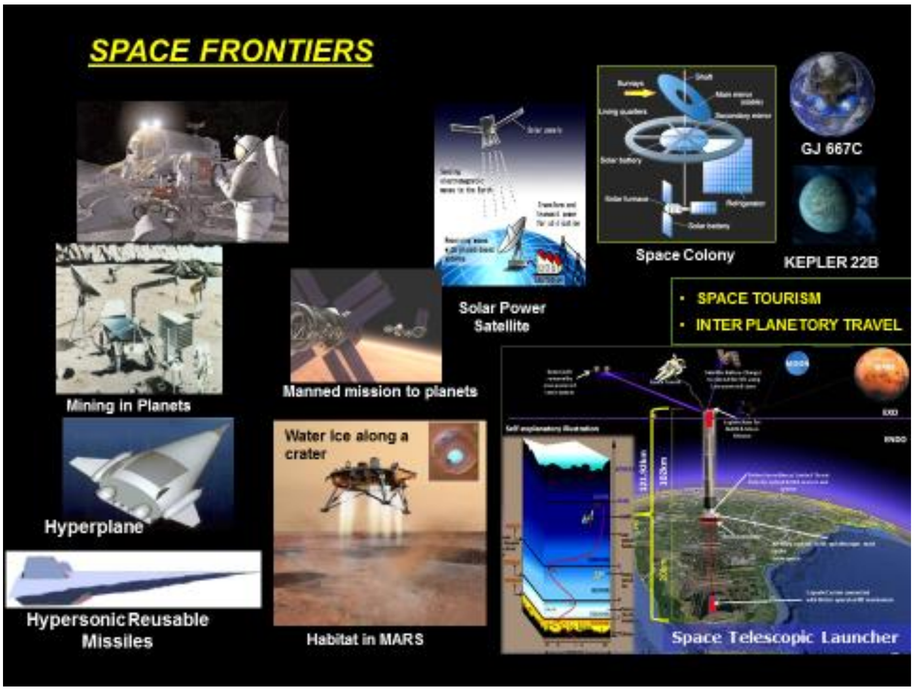
Futuristic Dominant Technologies

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.

100 years of Aerospace

Space will be the world's largest industry in the 21st Century. Over a period of time the earth's resources including fossil fuel reserves will be depleted. Further, the world population which is six billion today is expected to grow at a fast rate. Thus there is a pressing need to look for alternatives. Outer space habitation and mining can provide the answer with man now having the technological capability and foundation to take up major aerospace missions.

By the year 2030, it is expected that large international missions with multilateral cooperation will be taken up. The experience gained on account of past missions in the areas of propulsion, composite airframe, guidance and control etc. will lead to the development of unmanned combat air vehicle and hypersonic reusable vehicles which will make space transportation easier, reliable, safer, and cost effective. The cost structure of existing launch vehicle is high because space vehicles are expendable. Reusable launch vehicles can provide low cost access to space and space industrialization. The space tourism and launching of heavier payloads will thereby be more attractive. The development of hyperplane would be helpful in building solar powered satellite—a viable alternative to the looming energy crisis on account of the depletion of fossil fuels.



Studies have indicated that the availability of fossil fuels like oil, gas for power generation will be exhausted by 2075 and coal by 2100. Problems for

India will be more acute, even earlier. Therefore to meet this crisis large scale commercial utilisation of outer space can be made of with the construction of photovoltaic solar power satellites generating electric power for use on earth. Solar energy is available for 99% of the time in an orbit above the earth, where 1.43 kW of solar energy illuminates anyone square metre considerably greater than that received on earth's surface. The solar flux is converted into microwave energy and beamed down to receiving stations at off shore locations on earth. Studies have estimated that one SPS generating about 1000 MW would require 12 sq. km array of photovoltaic cells and would weigh 10000 tonnes. Therefore the construction of such satellites would require the use of Hyperplane for transportation to the low earth orbit to build the large satellite in space and tug it to the geo-synchronous orbit.

Space Based Solar Power

Studies have indicated that the availability of fossil fuels like oil and gas for power generation will be exhausted by 2075 and coal by 2100. Therefore, to meet the looming energy crisis, the development and large-scale commercial utilization of outer space has been suggested, with the construction of photovoltaic solar power satellites generating electric power for use on earth. Solar energy is available for 99 per cent of the time in an orbit above earth, where 1.43 KW of solar energy illuminates any one square metre considerably greater than that received on earth’s surface.

Large solar power stations convert solar flux into microwave energy and beam it down to receiving stations at offshore locations on earth. However, the construction of SPS in space would necessitate the use of Hyperplane, a heavy lift high efficiency space cargo vehicle, using advanced aerospace technologies for revenue-earning mass missions in space. Studies have estimated that one SPS generating about 1000 MW would require 12 sq km array of photovoltaic cells and would weigh 10,000 tonnes. Such SPS would take about 3 years for construction in space using a fleet of Hyperplanes to place construction materials in a low earth orbit.

Repair and Refuelling of Satellites in orbit

There are hundreds of operational commercial satellites and government spacecraft currently in orbit, many of which will run out of fuel long before they sustain electronics or other systems failures. Enormous amount has been spent on sending the satellites to orbit. The goal is to find an optimum solution for refuelling, repairing and servicing spacecraft in orbit. The advancements in Robotics and Artificial Intelligence will give a way for performing such tasks in space. The humanoid robots could be deployed in space for undertaking any repair of the satellites and for extending the lifetime of the satellites.

Collecting Space Debris

Space debris also known as orbital debris, space junk, and space waste is the collection of objects in orbit around Earth that were created by humans but no longer serve any useful purpose. These objects consist of everything from spent rocket stages and defunct satellites to explosion and collision fragments. The debris includes dust from solid rocket motors, surface degradation products such as paint flakes, coolant released by RORSAT nuclear powered satellites, clusters of small needles, and objects released due to the impact of micrometeoroids or fairly small debris onto spacecraft. As the orbits of these objects often overlap the trajectories of spacecraft, debris is a potential collision risk.

The vast majority of the estimated tens of millions of pieces of space debris are small particles, like paint flakes and solid rocket fuel slag. Impacts of these particles cause erosive damage, similar to sandblasting. The majority of this damage can be mitigated through the use of a technique originally developed to protect spacecraft from micrometeorites, by adding a thin layer of metal foil outside of the main spacecraft body. Impacts take place at such high velocities that the debris is vaporized when it collides with the foil, and the resulting plasma spreads out quickly enough that it does not cause serious damage to the inner wall. However, not all parts of a spacecraft may be protected in this manner, e.g. solar panels and optical devices.

There are several ways of dealing with debris. In order to mitigate the generation of additional space debris, a number of measures have been proposed. The passivation of spent upper stages by the release of residual fuels is aimed at reducing the risk of on-orbit explosions that could generate thousands of additional debris objects. Another process is self removal. Geostationary satellites will be able to remove themselves to a "**graveyard orbit**" at the end of their lives. It has been demonstrated that the selected orbital areas do not sufficiently protect GEO lanes from debris, although a response has not yet been formulated. Rocket boosters and some satellites retain enough fuel to allow them to power themselves into a decaying orbit. In cases when a direct (and controlled) de-orbit would require too much fuel, a satellite can also be brought to an orbit where atmospheric drag would cause it to de-orbit after some years. Another proposed solution is to attach an electrodynamic tether to the spacecraft on launch. At the end of their lifetime it is rolled out and slows down the spacecraft. It has also been proposed that booster stages include a sail-like attachment to the same end. The vast majority of space debris, especially smaller debris, cannot be removed under its own power. A variety of proposals have been made to directly remove such material from orbit. These range from large spacecraft capture and hazard mitigation to "laser brooms" for removing small pieces of debris.

Space Colony

With the world population topping 4 billion people and expected to reach over 30 bn within the next 100 years, efforts are being made to explore the possibility of accommodating people and building a city in space which could house several thousand inhabitants and boast of an environment identical to Earth. The colony will have air and water and lakes and mountains. It will have gravity and similar atmospheric structure, air pressure and temperature as existing on earth and people will be able to stand and walk exactly as they would do on earth. Light would be provided by massive reflective mirrors affixed on satellites that reflect sunrays to the colony. Living quarters would be a donut shaped area. Colony would also contain areas for agriculture, animals and plants and would weigh about 10 million tonnes.

Prof. Gerard K. O'Neil of Princeton University had visualized the space colony in the earth-moon L4 and L5 liberation points and established unique laboratory to experiment the theory of space colonization. A series of Heavy Lift Launch Vehicles (HLLV's) or Hyperplanes will carry hundreds of tons of cargo consisting of equipment to Low Earth Orbit (LEO). The assembly and transportation of this equipment meant for a space colony would be done by a ferry service called Space Tug. The new idea is to have a launch base at the moon which has less gravity as compared to the earth ($1/6^{th}$). This will reduce the weight of the launch vehicle and time for the flight.

There are two possibilities; one directly taking payloads to the space colony from LEO and the other route is to establish a minimum facility on the moon for material mining and reaching the L4/L5 point through catch point L2. This is because if the space colony is to be built at L4/L5 point between the earth and moon, it is thought better to transport the necessary building materials from the moon, due to its less gravity and rockets taking off from there would require less fuel. Because of this factor, a factory would need to be set up on the moon before work on the space colony could begin. Materials from the moon can be carried to the colony through lunar materials transfer vehicle and construction in space. The Milky Way now awaits for our conquest. It will happen in the next century that people will be living in space colonies and will be travelling to earth for holidays.

Space Industry

Space offers an enterprise for the future generation with next industrial revolution. Availability of exotic resources and low gravity manufacturing in moon and Mars have tremendous prospects for mankind. Mining in planets would need innovative methods for exploring, processing and transporting large quantities of rare materials to earth. The moon could become a potential transportation hub for interplanetary travel. The moon's sky is clear to waves of all frequencies. With interplanetary communication systems located on the far side, the moon would also shield these communication stations from the continuous radio emissions from earth. Hence, the moon has the potential to become a launch base for interplanetary travel and 'Telecommunications Hub'.

The future revolution

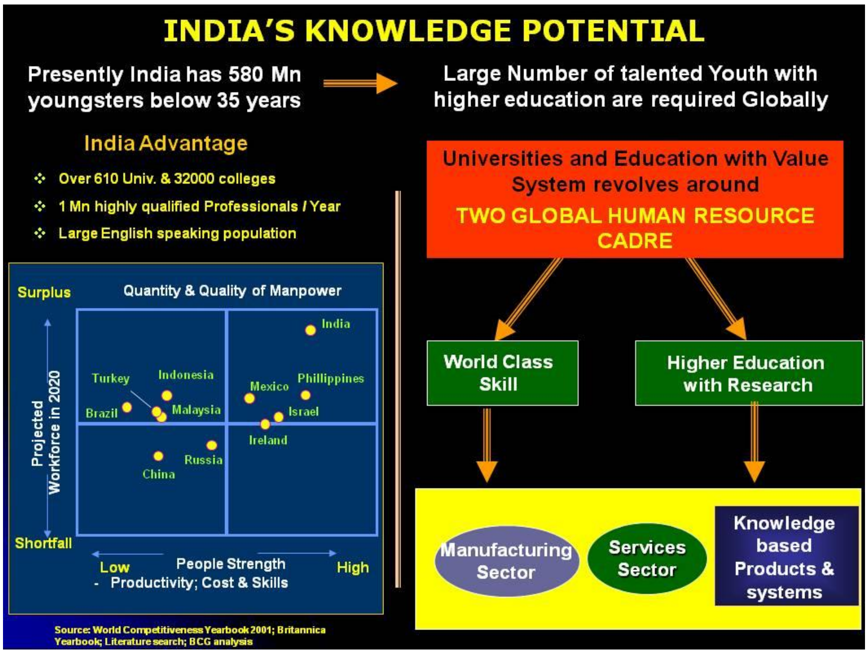
Man's quest for perennial sources of clean energy such as solar and other renewable energies and thermonuclear fusion would be filled through mining/exploration on the moon. Large deposits of Helium 3 in the moon and Mars provide a solution for future energy demand. Also, the dry ice deposits on the planets would be a source of fuel for rocket engines. 100 kg of Helium-3 would have a coal equivalent value of $140 million. Access to lunar helium-3 at competitive cost potentially offers an environmentally benign means of helping meet an anticipated nine-fold or higher increase in energy demand by 2050. Samples collected in 1969 by Neil Armstrong during the first lunar landing showed that helium-3 concentrations in lunar soil are at least 13 parts per billion (ppb) by weight. Levels may range from 20 to 30 ppb in undisturbed soils. But at a projected value of $1410 per gm, 100 kg of helium-3 would be worth about $141 million. The highest concentrations are in the lunar maria; about half the He3 is deposited in 20 per cent of the lunar surface covered by the maria. It is believed that there are large deposits of He3 that have been deposited by solar wind in the lunar soil. Since the lunar soil has been stirred by collisions with meteorites, possible availability of He3 in moon would be down to depths of several metres. That 1 million metric tonnes of He3, reacted with deuterium, would generate about 20,000 terra watt-years (one trillion (10 to 12^{th} power) watt-years) of thermal energy. Hence, the Helium 3 is the future.

Industrialisation in Moon will become necessity due to availability of resources and to take advantage of the reduced gravity. Even building large structures for space colonisation need to be carried out on Moon. Thus Moon will become the hub of transportation to liberation points and other planets. India was unfortunate to miss the first industrial revolution and was negated as developing country. Now, with the opportunity of a second industrial revolution knocking through the moon and mars missions, it is all the more important for India to go on a faster pace in manned missions leading to setting up of industry in moon and planets.

> **“The human race will get out of its cradle – the earth to explore the new frontiers of space, like a child gets out of its cradle to explore things around it.”**

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

In order to realize the great vision of India to become a Developed Nation, we need skilled human resource and creative leaders. Youth of our nation is to evolve a learning process to meet the demands of the missions. We need young leaders who can command the change for transformation of India into a developed nation embedded with knowledge society. 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 achieving "Developed India" Vision.

Conclusion

Prof. Satish Dhawan always thought of the Nation greater than himself. He was a leader with focused missions. He always had the passion to achieve the missions with a team of leaders he built, proving himself a Creative Leader. He always travelled into an unexplored path with honesty of purpose with high level of integrity. He gave the credit of success to his subordinate leaders and took the failures on himself thus motivating his team. His nobility and compassion in management has been remarkable. It would be ideal to say that he was a Creative Leader and Institution builder and a Creator of Creative Leaders and world class Organisations.

I would like to state that if India is to be a global leader, we need the creative leaders to have in mind:

"If we are expected to Achieve Results never before Accomplished,

We must employ Methods never before Attempted,

But with utmost honesty"

Thank you