भारतीय अंतरिक्ष विज्ञान एवं प्रौद्योगिकी संस्थान
तिरुवनंतपुरम

Indian Institute of Space Science and Technology
Thiruvananthapuram

चौथा दीक्षांत समारोह

अक्तूबर 15, 2016

Fourth Convocation

October 15, 2016

Convocation Address
Dr. V. K. Aatre

Chancellor's Address
Prof. U. R. Rao

Director's Report : **Dr. V. K. Dadhwal**

Dr. V. K. Aatre

(Former Secretary DDR&D and Director General, DRDO)

Chief Guest, Fourth Convocation, IIST

Prof. UR Rao, Sri Kiran Kumar, faculty and staff of Indian Institute of Space Science and Technology, graduating students, ladies and gentlemen; it is indeed my pleasure and honour to deliver the convocation address at this Institute. At the outset let me congratulate the graduating students who are to receive their degree in today's convocation. This is the culmination of years of study and some thing you can be proud off. In spite of vast number of educational institutions in India, you are a privileged few who had the opportunity to graduate from this upcoming institution started by the Department of Space.

Department of Space and ISRO have made us all proud with their successes over the years. Chandrayana, Mangalayana, launchingof multiple satellitessimultaneously and the most recent demonstration of scram jet technology are just a few of their achievements. Some of you will have the opportunity to work in such a glorious organization.

First degree is like a learner's license which allows you to practice as a professional engineer and technologist. You are not going too far based only on what you have already learnt and know so far. You have learnt a lot but there is lot more to learn in the coming years. Infact, you are going to advance in life by what you are going to learn after leaving this institution which has laid the requisite foundation for learning. As you progress you are going to be acquiring wisdom. Acquiring wisdom is a moral duty and it is not something you do toadvance your life.

There are a few things you should remember. You should find your own path to makeyour dreams real. Of course, you must have a dream to start with. Have courage to follow your heart and intentions. They know what you truly want to become and

you do not have to lead someone else's dream or life. Along the way remember that there are three intrinsic elements to your motivation and success – purpose, passion and perseverance. Do not be afraid to be fearless for as you walk along untraversed path obstacles loom large and negative soothsayers are aplenty.

I have been puttering around the field of science and technology. I had the opportunity to head the largest science and technology organization in the country. I had ample opportunities to interact with the Department of Space and ISRO. Rather than talk about these, I thought it would be more appropriate for me to share some general thoughts on science and technology and its impact on Society.

As we view the growth of science and technology through centuries, they have revealed a world never really dreamt of and never properly imagined. If we trace the history of human civilization from those dim yearseons ago to the present, we see that the science has changed our perceptions of the universe and indeed the perception of our role in the universe. Copernician revolution changed the geocentric universe of Aristotelian times to heliocentric universe; and Darwinian revolution showed that we are only a twig, albeit an important one, in the tree of evolution. Today science and technology has become so pervasive ant dominant that our societal behavior, our interaction and communication not only between individuals but between nations, our mode ofliving and recreation are allmodulated and dominated by the breath taking developments that have taken place in the world of science and technology. There is hardly anybody, whether they recognize or not, who is not touched by and affected by science and technology.

Science deals with ideas and is esoteric, curiosity driven, and an abstract cultural activity of a society. Technology is more mundane, application driven and looks at the utilitarian aspect of science. Twentieth-century technology is essentially all derived from science. The intimate interweaving and mutual enhancement of these two in the past century accounts for the ever escalating pace of both. Science begets technology, science uses technology to create more science. More science begets more technology.

It all began, as many believe, with Greek and Aristotle. Though Egypt, Mesopotamia and Indus valley had scientific traditions, it was the Greek philosophers – as they were called then – following Plato and his Academy and led by Aristotle who laid great emphasis on the search for 'absolute truth' and inquired into the nature and the nature's laws. Unfortunately,many of the laws and findings were flawed. For instances the concept of geocentric universe and all other planets going around the earth, Aristotle's laws of motions were not only flawed but, due to the dominance of Aristotle, had to wait for centuries for correct formulation – the former due to Copernicus and the later due to Galileo and Newton. Indeed, flawed were the human anatomical theories of Galen till they were corrected by Andreas Vesalius in the 16th century. But it goes to the credit of Greeks that Science became secular and a lay activity that could be pursued by people outside of the church; and reasoning and mathematics became central to the development of science. But Greeks abhorred manual work and observation which had to wait for nearly several centuries for becoming central to the scientific development.

The utilitarian aspect of science and technology and deviation from Aristotle's dogma had to wait for Francis Bacon who introduced the concept of experimental scientific methods. In his book New Atlantis, he visualized teams of people carrying out a multitude of experiments planned to embrace all possible enquires which were relevant to the welfare of the people and society. To illustrate this, he created an ideal society in remote island and a house - Solomona's house -where groups of scientists worked on various problems and methods of using science to the good of the society. Beacon gave a powerful motive for pursuing science and this led in some sense to the formation of research universities. Some believe that this lead to the formation of the Royal society whose fellowship is still the most coveted honour for a scientist. Beacon was followed by Galileo developing science based on observation and experimentation, and Newton, introducing mathematics into physics and discovering laws of motion followed by his seminal work on light and optics. In the following three and odd centuries a galaxy of scientists who with their collective intellectual might converted the arm-chair- reasoning science to its present 'benefactor of society' and a great enterprise.

Although Newtons 'Principia' demonstrated that science can lead to the better understanding of the world, it was left to the scientists of the 18th and 19th century to confirm Beacon's forecast that science can be used to advance out material welfare. This was further buttressed by certain influential Societies – like the Lunar Society with member like Wedgewood, Watt, Boulton and Priestly -putting scientists in much closer touch with the industries than the Royal Society. Industrial revolution showed the profound effect advances in technology could have on everyday life. The principal technological advances which

brought about these remarkable change where the mechanization of industrial process such as spinning and weaving, the substitution of steam engines for human, animal and water power, improvements in mining and working of raw materials, most notably iron. It is true that most of the technical advances of the industrial revolution, although helped by science, were not critically dependent on recent scientific discoveries. But this clearly led to the science based industries and knowledge became power, thus heralding the great developments of the 20th Century.

What can you say about the development in science and technology in the 20th Century? The quantum of knowledge gained in this century was far more than in the last several millenniums. At one extreme we probed the minutest of the minutest and the other end largest of the largest. We have developed two of the most fascinating theories viz Quantum Mechanics and the Theory of Relativity. We have made stupendous developments in microelectronics leading to supercomputer and thinking machines! We have split atom, unthinkable at one time not long ago, and harnessed its energy to satiate ever hungry world. Our research and developments in communication have shrunk the world creating notonly the ubiquitous cell phone butmaking all the information available literally at our finger tips. We have merged science and medicine to diagnose and cure several diseases. We have merged biology and technology and hold tremendous promise to feed the teeming millions of the world. Clearly this is an endless list as most aspects of human development and endeavor are affected, guided and controlled by science and technology.

The twenty-first century promises to explain the unexplainable and gives humanity opportunity to learn what until now has been unlearnable and unknowable – How did it all begin and how is it going to end? Is there an ultimate theory of everything explaining all that we know about nature? Are we alone in the universe? Can we solve the problem of space and overcrowding by space colonization? Can we cure genetic disorders and clone ourselves? Can we finally create the ultimate bionic human being? Can we fully understand how we function and find the site of consciousness? Infinite number of questions like these still persist. Of course, without inputs from technological developments we certainly will not be able to answer these and such questions. Whether or not we answer these questions, it is certain that Science and Technology will be the most important endeavor of people, society and the Governments.

It would be interesting to ask the common man and woman in a street, whether science and technology is really a worthwhile endeavor to pursue; and here what they maydsay. Few hundred years ago they mostly likely would have never heard of S&T;perhaps a century ago they would have acknowledged the presence of such an activity without much comment. But today, I feel they would talk about it as something which has made their lives more comfortable, improved communications, given them better health, faster and easier transportation and bought them better goods, services and entertainment. Perhaps some would say we cannot live without science and technology and feel that S&T would find answers for all human predicaments. Of course, some would be less optimistic.

Science and technology will inevitably bring in great changes to our lives. But will it lead us to utopia!. A question nobody would

venture to answer. But we must recognize that there is certain 'inevitability' to technology. It is bound to get more and more sophisticated and complex. We must also recognize that science and technology are not neutral activities. They can be used or abused- by intent or otherwise. When Enrico Fermi introduced nuclear fission, we looked to solve our energy problem by utilizing the enormous energy released in the process. The same process has also led to the development of nuclear arsenal. The exploitation of fossil fuels to satisfy our gargantuan needs for energy and transportation has led to global warming. Technology seems to give us power to wreck the environment. Genetic engineering and nano technology have so much to offer but also could lead to frightening consequences.

We have to accept that nothing comes without risk and science and technology are no exceptions. We must at least have a modicum of wisdom to use S&T to the good of humanity as Bacon envisaged. We must also realise that science and technology is too important to be left to scientists and technologists only. Philosophers, sociologists, psychologists and politicians, and even common men and women, must be aware and understand the impact of science and technology on their lives and should be somehow woven in to the decision making fabric.

India has had a long and glorious tradition in science and creativity. The well-planned civilization of Indus Valley, the great scientific discoveries of zero and the decimal systems and other important works in algebra, geometry and astronomy, the great tradition in metallurgy (remember the iron pillar of Delhi), superb capabilities in civil engineering and architecture are all illustration of scientific traditions and application of scientific

knowledge to real world problems. Charka Samhita's description of curing diseases and mental disorders, of problems and solutions of public health and holistic systems of health through ayurveda and Susrutha's treatise on surgery are clear indications that we were not behind in medical and health sciences either. However, for three hundred years, during the period of internecine strife and colonial domination, there was a general decadence with lack of positivism and of innovation. The great intellectual tradition of Indian Philosophy or of scientific reasoning that were seen earlier were nowhere on the scene; parochial bigoted narrow minded and conservative approaches took over the society;consequently, killing most creative activities. India, could not, therefore, take advantage of the scientific and industrial revolution when they took place in the west.

Fortunately for us there was renaissance in Indian Scientific activity during the twentieth century due to remarkable people like JC Bose, CV Raman, S Ramanujan, and M Visveswaraiah. Today once again our scientists and engineers have become a force to contend with. Our recent successes are applauded by the entire scientific and technological community of the world. Yet, S&T scenario in India needs several considerations and changes. Our university educational system, especially at the postgraduate lever where scientific work really gets done, require both qualitative and quantitative boost. Our engineers and technologists should 'invent and innovate' instead of imitating. Our industrial houses must get into research and development mode and get out of 'license production' syndrome. We must establish synergy between the academic community, R & D community and the industry. Indications are that we are on the right track; but the velocity of change and progress has to

increase considerably.

In the recent years India has indicated its intent and ambition to become a World Power. A country can become a world power only if it becomes an economic power. To become an economic power, it has to become a knowledge power; science and technology is at the hub of this knowledge. India has huge human resource. Young and talented people like you are the future of India. Resolve here and now that you are going to work professionally, diligently and with integrity to the betterment of the people of this country and indeed the whole world.

Once again my greetings and congratulations to all the students who are received the degree to day.

Thank you.

Dr. Vasudev Kalkunte Aatre

Dr. Vasudev Kalkunte Aatre is an eminent defence scientist and former Director General of the Defence Research and Development Organisation (DRDO), India's premier Defence research and development organization. In that capacity, Dr. Aatre also served as the Scientific Advisor to the Defence Minister. Dr. Aatre made outstanding R&D contributions in his capacity as Scientific Advisor to Defence Minister for five years.

Born in 1939 at Bangalore Dr. Aatre has reached the highest position in the Defence Research and Development Organisation due to his outstanding contributions in many spheres of defence technologies. Hailing from a family of high traditions and values, Dr. Aatre was brought up in an atmosphere conducive for his holistic development. Dr Aatre had a brilliant academic record and meritorious career in India and abroad. Dr Aatre received BE (Electrical) from the University Visvesvaraya College of Engineering (UVCE), then the part of the University of Mysore in 1961 and ME (Electrical) from the Indian Institute of Science (IISc), Bangalore, in 1963. Dr Aatre was awarded a PhD in Electrical Engineering from the University of Waterloo, Canada, in 1967.

After his PhD, Dr. Aatre joined the Technical University of Nova Scotia, Halifax, Canada, and worked till 1980, even as he was a visiting professor at IISc, Bangalore. Dr Aatre joined DRDO at the Naval Physical & Oceanographic Laboratory, Cochin in 1980 and became its Director in a quick span in 1984.

Dr Aatre was later appointed as Chief Controller (R&D) of DRDO. In February 2000, he has become the Director General of DRDO and Scientific Advisor to Defence Minister. He retired in October 2004.

Having played a vital role in the development of a wide spectrum of electronic technology and deeply involved in

human resource development in DRDO, Dr Aatre spearheaded the development of underwater technology for the Navy through the design and productionisation of state-of-the-art transducer and sonar suits.

"The first indigenous construction of a well-instrumented ocean acoustic research ship Sagardhwani materialised due to his vision and leadership. Dr Aatre has been at the hub of the development of complex and sophisticated integrated electronic warfare systems for the Indian Army and Navy," DRDO says in one of its tributes to Dr Aatre.

Dr Aatre has published over 50 technical papers in national and international journals and authored textbooks for graduate and under-graduate levels.

To his credit are, national awards, including DRDO Scientist of the Year Award (1986), VASVIK Award for Electronics Science & Technology (1990), IETE Ram Lal Wadhwa Gold Medal for Electronics & Telecommunications (1993), and DRDO Technology Leadership Award (1998).

Dr. Aatre gave new impetus to R&D programmes of national importance such as development of Light Combat Aircraft (TEJAS), Kaveri Engine for LCA, Electronic Warfare, Main Battle Tank (MBT) Arjun and Missiles. Dr. Aatre who has set the DHWANI, a keynote for research in the field of Under Water System SONARS and Torpedoes in the country. He was instrumental in the development of oceanographic ship 'Sagardhwani' for oceanographic research. Dr. Aatre was able to convince the political leadership, bureaucrats and scientific fraternity to achieve the high goals he had set for himself and the DRDO during his tenure as head of DRDO. A compilation of his brief biography and impressions of his colleagues and friends was published with the title 'Soaring High (A Biography of Dr. V. K. Aatre).

Dr Aatre was awarded the Padma Bhushan award in 2000 by the then President K. R. Narayanan. Dr was bestowed with Padma Vibhushan award, India's second highest civilian award in 2016.

Prof. U. R. Rao

Honourable Chancellor, IIST

Chairman, PRL Council

(Former Chairman, ISRO & Secretary, DOS)

Dear friends,

I am delighted to participate in the Fourth Convocation of the Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram. IIST. In a short span of just 10 years, IIST has developed into an unique institution offering a complete range of undergraduate, post graduate, doctoral programmes with specific focus on space science, technology and applications. I offer my hearty congratulations to all the graduating students and my very best wishes for their illustrious future.

1. Introduction

In the seventeenth century, India was a major player in the global export market accounting for over 25% of world's output. Gross neglect of science and technology in the 18th and 19th centuries, during and after the industrial revolution, resulted in the catastrophic decline in India's global output, from 25% to just 2.5%. It is only after independence, India seriously started the development of science and technology.

Remarkable progress made in the development and use of space technology, since the beginning of the space age in 1957, and the mind boggling applications of space technology during the last 6 decades have virtually revolutionized our lives. The capability of communication satellites placed 36000 km above the earth's equator for providing continuous communication to a third of the globe, first proposed by Sir Arthur C. Clarke in 1945,

initiated global communication revolution. This was followed by remote sensing satellites orbiting in a sun synchronous polar orbit to provide accurate data and detailed information on agriculture, forestry, weather, disaster management, and a variety of vital social applications.

2. Development of Space Technology in India

Dr. Vikram Sarabhai, the father of the Indian Space program, had the vision to realise the tremendous potential of space technology not only to explore the universe but also for our national development. A humble beginning of the Indian Space endeavor was made in the Mary Magdaline Church in Thumba, Thiruvananthapuram in 1963 with a strong vision of fully harnessing space technology for the benefit of our country. Realising the unique capability of space technology for tackling basic problems such as nationwide communication, education, weather monitoring, disaster management and management of agriculture and forestry, ISRO undertook the development of satellite technology on a war-footing. ISRO's first satellite Aryabhata, which was built from scratch in 2.5 years, in sheds in Bangalore, was successfully launched from USSR in 1975. This was followed by the successful launch and operationalisation of the two experimental remote sensing satellites in 1979 and an experimental communication satellite in 1982, which enabled ISRO to boldly venture into the design and fabrication of the state-of-the-art, operational remote sensing, communication, navigation as well as scientific satellites.

In order to attain total self-reliance in space technology, ISRO parallelly focussed on developing rockets for launching its own remote sensing, communication as well as scientific satellites. Starting with a simple rocket SLV-3 in 1983, capable of launching 40 kg into a 400 km orbit, ISRO has now fully operationalized ASLV, PSLV and GSLV rockets capable of launching over 300 kg satellites into Geostationary Orbit. In the past two and a half decades ISRO has successfully carried out over 75 major satellite launches which have revolutionized the country's telecommunications, TV broadcasting, DTH services, business communication, rural area connectivity, Tele-education, Tele-medicine, weather prediction, emergency communication and navigation.

3. India becomes a significant Space Science player

Since the advent of space age, truly mind boggling discoveries in space have been made which have enabled us to take a close look at other planets, stars, galaxies and the universe itself. Practically every year since the beginning of space age, space ventures have come out with great discoveries enabling us to understand the evolution of our universe since its origin 13.7 billion years ago. Scientists have discovered extremely interesting space objects such as x-ray stars, neutron stars, pulsars and even black holes. Space scientists have been able to take a detailed look at not only our own solar planets but also extra-solar planets elsewhere in our galaxy.

While focusing on the application of space technology for the extensive socio-economic development of the nation, ISRO has also made a significant impact in space science exploration. ISRO has successfully carried out a few important scientific missions such as Meghatropiques for meteorological investigations and Astrosat for carrying out detailed investigations of x-ray stars. Our Chandrayaan mission to the Moon had the unique distinction of discovering water on the Moon for the first time. ISRO succeeded in its very first attempt to send a satellite around Mars and carry out investigations of Martian terrain and its atmosphere. ISRO is now planning to launch its most ambitious solar mission in 2018-19, by placing its satellites Aditya-1 and Aditya-2 over L1 and L5 Lagrangian points to carry out detailed investigation of the solar corona. The next Chandrayaan mission is planned to take place during 2018-19, which will carry a lander to land on the Moon and a rover to carry out scientific investigations on Moon's surface. The next mission to Mars is being planned to be carried out in the next 3 or 4 years for carrying out detailed investigation of Mars terrain and its atmosphere.

In spite of the truly modest space budget of India, which started with an annual budget of just one crore a year and has only recently reached 5000 crores, ISRO has established itself as one of the five leading space powers. In association with the other user ministries, ISRO's contribution for providing valuable nation-wide services in communication, education, meteorological services, disaster management, fisheries,

forestry, agriculture and management of natural resources, tele-health services are unmatched anywhere in the world. In addition, ISRO has also been providing assistance to many world countries in a number of areas, thereby earning over half of its own budget.

5. Future Directions in Space

While space ventures during the last 60 years have brought a great change in our life style, they have also raised our expectations. The future space scientists like you will have to find solutions for some of these challenges.

EIGHT GREAT CHALLENGES IN SPACE

1. Food Security (Precision Farming / Ever Green Revolution)
2. Energy Security (Energy Crunch – Space Solution)
3. Resource Security (Planetary Exploitation)
4. Environmental Security (Global Warming, Climatology)
5. Space Security (Space Debris – Space Weaponisation)
6. Cheaper Space Transportation (Reusable Launchers)
7. Search for life (Planetary Hunt)
8. Colonisation of Mars (Permanent Habitat Development)

Radical expansion of space activity can occur only by drastically bringing down the cost of space ventures; which means we must quickly bring down the cost of space launches. Serious attempts are being made to develop air breathing systems for upper stages

to substantially increase the mass of deliverable payload. It is obvious that the only way to drastically bring down the cost of space launches is by developing recovery and reuse of rocket launchers. The entry of private parties Pioneered by Elon Musk (Space X), Jeff Bezos (Amazon), Richard Branson (Virgin Galactic) etc., who are heavily investing in the development of space technology will no doubt greatly speed up in achieving reliable reusable launchers, to substantially reduce the cost of space journey.

6. A Glimpse of the Future

Intensive exploration of other planets, detection and exploitation of planetary resources for energy, minerals and expensive metals including gold and platinum, and eventual establishment of large scale self-sustainable human colonies are bound to be humanity's next goal. Increased participation of private parties will no doubt help in achieving our goal of intensive space exploration at affordable cost, provided they are assured of reaping reasonable profit from their investment. Recently US Government seems to have approved a law allowing private parties to exploit minerals or other deposits from other planets, even though they cannot claim any rights over the terrain, just as people have the right over the fishes they catch in the ocean but cannot claim sovereignty over the ocean.

A number of leading scientists firmly believe that next great step in space exploration, will be colonization of Mars. Mars is our

nearest neighbor planet, even though compared to our earth it has less than 1% oxygen and reaches -140°C at nights, while the day time temperature is quite benign. Scientists have been discussing how to create an atmosphere and a greenhouse effect to raise the night time temperature as well as increase oxygen content in Mar's atmosphere to make it habitable. Many of us firmly believe that with the help of human interaction, we will be able to make Mars habitable and colonise Mars within the next 500 years.

I believe that we are on the threshold of a totally new and exciting era, when human beings, for the first time in history will be able to jump out of our cradle earth and start exploring and exploiting other planets.

7. Conclusion

My dear young friends, time and history have assigned you an unique role and responsibility of leading our nation at a very critical and turbulent period. It is in your hands to seize this opportunity, which you can do, provided you dedicate yourselves to the pursuit of the new vision of making India into an economically strong, scientifically progressive and technologically advanced nation. The spectacular developments in science and technology which you will witness in the next 50 years will be far more stupendous compared to the achievements of the last five decades. Phenomenal progress is being made in Robotics which can think and perform a variety of new tasks.

Biologists are on the verge of developing molecular medicine using new tools of genetic engineering, which can result in effective health care system based on predictive treatment. Space scientists are planning to build a lunar observatory, exploit mineral resources from other planets, build elevator to the Moon and establish human habitat on Mars. You have a great and exciting future, full of challenges, if only you can make use of your education and equip yourselves for grabbing the new opportunities.

If you do not want to be frozen in history, you must liberate yourselves through new ideas, discoveries and inventions to create a prosperous, just and equitable society. If only you can dare to dream and back-up your dreams with dedicated hard work and firm commitment, you will no doubt succeed in enabling this nation, as an inheritor of proud civilisation, to once again occupy its rightful place in the comity of nations. If you succeed, you will be writing a new chapter in our history and India will once again emerge as a most powerful nation. ***As Pandit Jawaharlal Nehru emphatically stated "It is an inherent obligation of a country like India, with its tradition of scholarship and original thinking and its great cultural heritage, to fully participate in the march of Science, which is probably mankind's greatest enterprise today".***

I wish all of you a long and bright future and pray that you be bestowed with the necessary courage, vision and wisdom to act as torch bearers of new India.

Jai Hind.

Prof. Udupi Ramachandra Rao

M.Sc., Ph.D., F.A.Sc., F.N.A., F.T.W.A.S., F.W.A.A.S.

Prof U R Rao is an internationally renowned space scientist who has made original contributions to the development of space technology in India and its extensive application to communications and remote sensing of natural resources.

Prof. Rao was the Director of ISRO Satellite Centre at Bangalore during 1972-1984 and Chairman of the Indian Space Research Organisation and Secretary (ISRO) during 1984-1994. Presently he is the Chairman of the Governing Council of the Physical Research Laboratory, Ahmedabad / Chairman, Karnataka Science & Technology Academy / Chairman, Advisory Committee for Space Science, ISRO / Chancellor, Indian Institute of Space Science and Technology.

Prof Rao started his career as a cosmic ray scientist, under the late Dr. Vikram Sarabhai, which work he continued at MIT during 1960-1963. In association with the JPL group, he was the first to establish the continuous nature of the solar wind and its effect on geomagnetism using Mariner 2 observations. After joining the then South West Center for Advance Research (which is now University of Texas at Dallas), Prof. Rao carried out many experiments during 1963-1966 as one of the prime experimenter, on a number of Pioneer (pioneer 6,7,8 & 9) and Explorer (Explorer 34, 41) spacecrafts which, led to a complete understanding of the solar cosmic ray phenomena and the electromagnetic state of the interplanetary space. After his return to India in 1966 Prof U R Rao and his group also carried out extensive work in X-ray and Gamma Ray high energy astronomy using rocket and satellite borne payloads.

Convinced of the imperative need to use space technology for rapid development, Prof. Rao undertook the responsibility for the establishment of satellite technology in India in 1972. Under his guidance, beginning with the first Indian satellite 'Aryabhata'

in 1975, over 20 satellites including Bhaskara, APPLE, Rohini, INSAT-1 and INSAT-2 series of multipurpose communication and meteorological satellites as well as the sophisticated IRS-1A and 1B remote sensing satellites were designed, fabricated and launched. He was also responsible for the development of the second generation remote sensing satellites IRS-1C and 1D.

After taking charge as Chairman, ISRO and Secretary, Department of Space in 1984, Prof. Rao accelerated the development of rocket technology in India, resulting in the successful launch of ASLV rocket in 1992. He was also responsible for the development of the operational PSLV launch vehicle.

Prof. Rao has tirelessly worked towards the utilisation of the vast benefits from space technology for the development of India. INSAT's initiated a total communication revolution in India, providing nationwide communication, TV Broadcasting, Developmental Education, Radio-Networking, Multimedia, Meteorological and Disaster Warning Services. Even after his superannuation in 1996, Prof. Rao continues to actively promote the application of space technology for education, agriculture, remote sensing of national resources and meteorological applications.

Prof Rao has published over 300 scientific and technical papers in various national and international journals covering cosmic rays, interplanetary physics, high energy astronomy, space applications and satellite and rocket technology. He has authored many books, notable amongst which are "Perspectives in Communications", "Space and Agenda 21 - Caring for the Planet Earth", "Space Technology for Sustainable Development" and “India's Rise as a Space Power”.

Prof. Rao is an elected Fellow of many prestigious academies. Pro. Rao was conferred Fellowship of the World Academy of Arts & Sciences. Prof. Rao, was the General President of the

Indian Science Congress Association for 1995-96. Prof. Rao, was the Vice President of International Astronautical Federation (IAF) during 1984 to 1992 and was the Chairman of the Committee for Liaison with Developing Countries (CLIODN) for over 15 years. Prof Rao was elected as the Chairman of United Nations - Committee On Peaceful Uses of Outer Space (UN-COPUOS) during 1997-2000 and also Chairman of UNISPACE-III Conference held at Vienna during 2000. Prof. Rao was elected as the Chairman of the 30th International Antarctic Treaty Consultative Committee Meeting at Delhi in April 2007.

Prof. Rao is the recipient of many prestigious national awards such as Vikram Sarabhai Research Award, Shanti Swarup Bhatnagar Memorial Award, National Design Award and VASVIK Research Award. He was also awarded Aryabhata Award, Om Bhasin Award, Jawaharlal Nehru Award, Gujar Mal Modi Science Foundation Award, Life Time Contribution Award of INAE, of Indian National Academy of Engineering, Vishwa Bharathi Award, Jawaharlal Nehru Birth Centenary Award from the Indian Science Congress Association, ISCA General President Gold Medal and Sivananda Eminent Citizen Award 2011. Prof. Rao received Life Time Achievement Award of Indian National Academy of Engineering and the first Life Time Achievement Award from the Indian Space Research Organisation on June 8, 2007. He was also awarded the Distinguished Scientist Gold Medal of the Karnataka Science & Technology Academy in August 2007.

Prof. Rao has also received many international awards, notable among which are Group Achievement Award of NASA, Yuri Gagarin Medal of USSR, 1992 Allan D. Emil Memorial Award for International Cooperation, Frank J Malina Award for space education by the International Astronautical Federation, Von Karman Award of International Academy of Astronautics, Vikram Sarabhai Medal of COSPAR and Eduard Dolezal Award of ISPRS. The prestigious Space Magazine, Space News named

Prof. U.R. Rao as one of the Top 10 International Space Personalities who have made a substantial difference in civil, commerce and military space in the world since 1989.

Prof Rao is a recipient of D.Sc (Hon. Causa) from more than twenty five Universities including the oldest University in Europe, University of Bologna (Italy).

Prof Rao was awarded 'Padma Bhushan' by the Government of India in 1976, which is the second highest Civilian Award. Prof. U.R. Rao became the first Indian Space Scientist to be inducted into the highly Prestigious "Satellite Hall of Fame" at Washington DC, USA on March 19, 2013. Prof. U. R. Rao became the first Indian Space Scientist to be inducted into the highly Prestigious "IAF Hall of Fame" at Guadalajara, Mexico.

Dr. Vinay Kumar Dadhwal
Director and Chairman, BoM, IIST

Most Respected Chancellor, Prof U R Rao, Honorable Chief Guest, Dr. Vasudev Kalkunte Aatre ji, former Director General of Defence Research & Development Organisation (DRDO) and Scientific Advisor(SA) to Raksha Mantri(RM), Government of India, Chairman, Governing Council, IIST & Chairman Space Commission, Secretary, Department of Space Dr A. S. Kiran Kumar, Members of IIST Governing Council and Board of Management, former Directors of IIST Dr B. N. Suresh and Dr K S Dasgupta, Degree recipients, Distinguished Guests, my Colleagues at IIST, Ladies and Gentlemen Very Good morning to all of you;

It is my privilege to extend a warm welcome to all of you to the 4th Convocation of our Institute. It is an honor to have amongst us a very distinguished technologist, Dr VK Aatre as the Chief Guest on this solemn occasion to deliver the convocation address.

Dr Aatre is a Fellow of Indian National Academy of Engineering(INAE), was born in 1939 in Bangalore and completed his BE in Electrical Engineering from University of Mysore in 1961, a master's degree from the Indian Institute of Science (IISc), Bangalore, in 1963 and a PhD in Electrical Engineering from the University of Waterloo, Canada, in 1967.Until joining DRDO at the Naval Physical & Oceanographic Laboratory (NPOL), Cochin, in 1980 he was Professor of Electrical Engineering at the Technical University of Nova Scotia, Halifax, Canada. He was appointed Director of NPOL in 1984 and he succeeded Dr Abdul Kalam as the Director General of DRDO and SA to RM in 2000. Dr Aatre was conferred the Padma Bhushan award in 2000 and Padma Vibhushan award in 2016.

It is indeed a great privilege for me to submit, during the Fourth Convocation a brief report on the activities of the institute. However before I do so, permit me to dwell on some aspects of

the 4th Convocation itself. In the first three convocations, held in 2012, 2013 and 2015, institute conferred degrees on students who completed their courses in 2011, 2012 and 2013, respectively, all with Dr APJ Abdul Kalam as the Chancellor. Thus in current convocation students who completed courses in 2014, 2015, 2016 will be conferred degrees under the Chancellorship of Prof UR Rao. Institute very fondly remembers the first Chancellor for his guidance and benevolence. It is a very happy coincidence that the 4th convocation is being held on 85th birth anniversary of Dr Kalam.

IIST is the first institute of its kind in the country, to offers undergraduate, post-graduate, doctoral and post-doctoral programmes and undertake research in areas with special focus on Space sciences, Space-related technology and its applications. It was established by Department of Space with a vision to be a world class educational and research institution contributing significantly to space endeavours and was formally inaugurated on 14 September 2007. In 2008 IIST received the recognition of UGC as a 'Deemed to be University' under Section 3 of UGC Act, 1956. IIST functioned from its Thumba VSSC campus from 14 September 2007 to 14 August 2010 and moved on 15th August 2010 to its own 100 acre campus at Valiamala, Thiruvananthapuram on the foot hills of Sahyadri mountains.

Undergraduate program with BTech in Aerospace Engineering, Avionics and Physical Sciences was first program established along with inauguration of IIST. Currently, the modified undergraduate program comprises of BTech in Aerospace Engineering and BTech in Avionics, each with 60 seats annually and a dual degree program with BTech in Engineering Physics with 20 seats. Dual degree students continue their studies to acquire MTech in Optical Engineering or MS in Astronomy or Astrophysics, or Earth System Science or Solid State Physics.

Admission for all three undergraduate programs is open national selection through direct counselling of students based on their performance in JEE(Main) conducted by CBSE and performance in Class XII School Board Exam as well as JEE(Advanced) Examination conducted by IIT. 138 and 140 students were enrolled in July 2015 and July 2016, respectively.

Unique features of undergraduate program of IIST is availability of merit scholarship of all students who maintain a high CGPA and an opportunity to be considered for absorption in ISRO subject to high CGPA and vacancies notified by ISRO. To encourage meritorious BTech degree students, the institute has instituted gold medals, namely, the (i) the Chairman, Governing Council's Gold Medal to the best for best academic performance, (ii) the Director's Gold Medal for best All-Rounder performance covering academics as well as in extra-curricular activities, and (iii) Gold medals to the academic topper of each BTech stream Aerospace, Avionics and Physical Science.

The Institute initiated MTech program in 2010 with two courses, while in 2012 four new courses introduced, while this year a new course on Power Electronics has been introduced. Institute is currently offering 15 MTech/MS programs. The admission is based on initial screening based on GATE score followed by test and interview. During 2015 89 students were enrolled in MTech/MS programs and the corresponding number is 79 this year.

IIST introduced a high value fellowship PhD program and out of 11 students under this program 10 have completed PhD and have been offered jobs in ISRO Admission for regular PhD is based on test and interview and is restricted to those candidates who have qualified GATE/UGC/CSIR NET-JRF/JEST. The admissions are done in January and July and since last convocation 75 PhD students have been enrolled thus taking

cumulative PhD enrolment to 150.

A Student Activity Board (SAB) under guidance of Dean (Student Activities) and with active participation of students through various committees and clubs provides a unique opportunity to acquire soft skills. The students organize and manage an inter-collegiate cultural festival named “Dhanak” as well as an inter-collegiate technological festival named “Conscientia” every year. Conscientia2016, the eighth Annual Technology and Astronomy fest of IIST was organised in march 2016. These provide a platform for the students to showcase their talents and creativity both in the cultural as well as in the technological domains. Dhanak2015 was organised during October 16 to 19 with inauguration by Shri Rajiv Nath with 40 events and participation of 1200 students. Fifth edition of IIST Annual United Nations was held in April 2015.

Under the guidance of IIST Faculty and the ISRO Scientists, with a view to provide knowledge and hands-on experience to the students to design, develop and build space systems and to work in teams in a project mode. Students of our Institute have also taken up the design of the VYOM-MK II Sounding rocket after successful launch of the VYOM-MK I on May 11, 2012. VYOM-MK II aims at doubling the payload capacity to 20Kg and increasing the peak attitude from 14Km to 70 Km. The main challenge is to do this while maintaining the simplicity and reliability of a single stage rocket. The student team has also analysed feasibility of drag separation with the current design as payload separation would provide then an altitude gain of 20 km as predicted by optimization study.

The IIST small-satellite program was taken up to encourage the interdisciplinary activities among the student community. As part of this program the students are encouraged to design and develop various subsystems of small-satellites under the guidance of IIST Faculties and ISRO scientists. Workshops on

Small-satellites were conducted at IIST for the students in collaboration with international organisations. Impressed by the student satellite activities at IIST, international organisations have shown keen interest in participating with IIST for the design and development of small-satellite space missions. Presently, discussion on two such missions, namely, Autonomous Assembly of Reconfigurable Space Telescope (AAReST) with Caltech University, USA, University of Surrey, UK, JPL, USA and International Satellite Program In Research and Education (INSPIRE) with University of Colorado, USA are underway. IIST envisages continuous activity on small spacecraft missions to provide a low-cost platform for technology demonstration and space research through students participation.

An Advanced Propulsion and Laser Diagnostics (APLD) centre is established under Department of Aerospace Engineering to conduct academic research in propulsion and laser diagnostics areas, which would positively contribute to ISRO activities in the related areas. As part of the ongoing research activities in this centre during the last academic year, the following major studies were carried out:

- Investigation of the altitude compensating capabilities of 'Expansion-Deflection (E-D)' nozzle.
- Performance evaluation of swirl injector in 10 N vernier engine of PS4 stage using droplet size and velocity measurements.
- Study on supercritical jet behavior of fluoroketone to mimic Liquid hydrogen injection into thrust chamber.
- Extensive studies on supersonic cavities to enhance noise suppression capabilities in flight/launch vehicles.

Similarly significant progress has been reported by the Centre of Excellence in Virtual Reality. An electron-ion coincidence set up was designed fabricated, tested and made operation in October 2015 in Department of Physics. A gas sensor calibration facility was established in Department of Avionics and Research Laboratory in MEMS and Micro/Nanoelectronics is being established.

Targeted research for Indian space program was strengthened with the establishment of Advanced Space Technology Development Cell (ASTDC) in the institute in October 2015. Ongoing IIST-ISRO projects were brought under its ambit and extensive discussions were held with ISRO/DOS unit to identify new projects and 38 projects are under active efforts. Already some of the projects have shown significant progress, namely:

- Design and development of Ka band data reception system (with NRSC)
- Signal Processing of Multi Object Tracking Radar data (with SHAR)
- Design and development of high performance hydrogen sensor (with IPRC)
- Computational fluid dynamics of methane/ liquid oxygen pre-igniter (with IPRC)
- Design and development of ASICS(with SCL):two ASICS, programmable gain difference amplifier and 14 bit 1MPSR SAR ADC
- Intrinsically conducting polyimide composites with CNT or graphene.
- As part of comprehensive stationary plasma thrusters instrumentation (with LPSC) a number of probes have been tested and delivered. These include Langmuir probe, Faraday probe EXB probe Retarding Potential Analyser and Parallel Plate Analyser.

The cumulative enrolment of the institute on September 1 this year stands at 2016 with program-wise distribution as. Undergraduates 1442, post graduates 389 and doctoral enrolment 185.After degree to be conferred in this convocation, the total degrees awarded by the institute will be 1003, comprising of 769 BTech, 207 MTech and 27 PhD Out of successful BTech students 101 and 103 were offered placement in ISRO in 2015 and 2016, respectively. Thus a total of 674 graduates from institute have joined ISRO.

In 2015-16 institute filed 3 patent applications, thus bringing cumulative patents filed number to 10. It is the institute's policy to protect its intellectual property and license its technologies for wider industry's use.

IIST has become a full member of the Square Kilometer Array(SKA)-India consortium. SKA is the next generation radio telescope of extremely high sensitivity (50 times better than that of the current biggest radio telescope) and angular resolution. The project is managed by an international consortium of 11 member countries including India. IIST is also a part of Indo-Belgium DST funded project on "Belgo-Indian Network for Astronomy & astrophysics (BINA)"

IIST is ranked eighth among all Indian Universities in April 2016 by the National Institutional Ranking Framework, set up by the Ministry of Human Resource Development (MHRD), Government of India.. Faculty and researchers submissions in conferences and symposia received around 13 best paper or poster award and two of the faculty were awarded IEEE Senior Membership in 2015-16.

Institute and developed a vigorous outreach program to spread the space technology and science to students beyond its register as well as other stakeholders. This comprises of Institute's various activities conducted in its campus such as Conferences,

Workshops and Short Courses. Two student managed outreach events and faculty participation in organising and participating in various technical events in India and abroad. After the last convocation, Institute organised .8 events during 2015, namely:

- National Conference on Material Science & Technology –NCMST2015 (Jul 2015, 3 day)
- 3rd Young Talent Nurture (for grooming students in Mathematics), (May-Jun 2015, 14 day)
- Summer School on Geospatial Technologies, (Jun 2015; 5 day)
- Automatic Control Systems and Design with MATLAB/SIMULINK (May 2015; 4 day)
- Control Engineering Analysis & Design with MATLAB/SIMULINK (Dec 2015; 4 day)
- Power Electronics for Space Systems (Dec 2015; 3 4 day)
- Research Methodology in Cultural Studies (Jun 2015; 4 day)
- The Thirty Meter Telescope-India Science and Instrumentation Workshop (Jun 2015; 3 day)

During 2016 till now 5 such events have been conducted while 4 more are scheduled in the month of December. The events completed in 2016 include:

- National Conference on Material Science & Technology –NCMST2016 (Jul 2016, 3 day)
- 4th Young Talent Nurture (for grooming students in Mathematics), (May-Jun 2016, 14 day)
- Workshop on Modern Optical Engineering (Jun 2016;6 day)

- Nonlinear Control System Design (nCSD) Jun 2016; 5 day)
- GeoConnect 2016: Orientation in RS& GIS for Natural Resources and Environment Management (Jul 2016; 5 day)

These activities of Conferences/ Workshop and short courses are important in dissemination technical knowledge beyond the regular students of IIST.

We would like to acknowledge the support received in abundant measure from the Department of Space, Government of India. I personally acknowledge the support and encouragement I have received from our beloved Chancellor, Prof U R Rao, our Chairman, Governing Council Dr A.S. Kiran Kumar, and Members of Governing Council, Members of our Board of Management, and from all my colleagues, and extend my appreciation to the students for their exemplary behavior and their contributions towards enriching the campus life.

Before I conclude, it is my duty to once again thank our esteemed Chief guest Dr V K Aatre, our Chancellor, Prof U R Rao, our Chairman of Governing Council, Dr A S Kirankumar, the degree recipients and our distinguished guests for their presence here today.

To our passing out students, I would like to convey my heartiest congratulations and best wishes to each one of the 378 BTech graduates, 178 MTech and 16 PhD degree recipients, and the student toppers receiving the gold medals for their special achievements.

Thank You.

Dr. Vinay Kumar Dadhwal

Dr. Vinay Kumar Dadhwal is the Director and Chairman, BoM of Indian Institute of Space Science and Technology, Thiruvananthapuram. He was the Distinguished Scientist & Director of the National Remote Sensing Centre (NRSC), Hyderabad. Dr. Dadhwal, born on April 9, 1957 did his graduation in Botany from Hansraj College, Delhi University and M.Sc in 1978 & Ph.D in Plant Physiology from Indian Agricultural Research Institute in 1983. Dr Dadhwal joined in the Space Applications Centre (ISRO), Ahmedabad as Scientist in 1983 and he was the Head, Crop Inventory & Modeling Division during 1998-2004. During 2004-2010, Dr Dadhwal served as the Dean, Indian Institute of Remote Sensing (NRSC), Dehradun, which is premier training and educational institute set up for providing training in Remote Sensing, Geoinformatics and GPS Technology for Natural Resources, Environmental and Disaster Management. In April 2010 Dr Dadhwal has become the Associate Director, National Remote Sensing Centre (NRSC), Hyderabad and he served as the Director of NRSC from 2011 to 2016.

Dr. Dadhwal worked on remote sensing applications to crop forecasting at district to national scale, irrigation management, sensor parameters for agriculture applications. His research interests include crop modeling, remote sensing applications in agriculture, land cover land use change modeling, land surface modeling, terrestrial carbon cycle and global change.

Dr. Dadhwal has made remarkable contribution as the Project Director, National Carbon Project of ISRO Geosphere Biosphere project and on Science Panel of CTCZ of Department of Science & Technology (DST). Dr Dadhwal's experience and activities related to UN Committee on Peaceful Uses of Outer Space (UNCOPUOS) at UN Office of Outer Space Affairs (UNOOSA), Vienna, includes:

(i) Chair of 53rd Session of STSC (Science & Technology Sub Committee) of UNCOPUOS, Feb 15-26, 2016;

(ii) Head of Indian Delegation to UNCOPUOS, 58th Session (2015), 57th Session (2014) and Member Delegation 56th Session (2013);

(iii) Leader of Indian Delegation to S&T sub-committee of UNCOPUOS,52 Session (2015), 51 Session (2014) and 50 Session (2013),

(iv) Chair, Working Group of Whole under S&T SubCommittee of UNCOPUOS (2013, 2014, 2015)

Dr. Dadhwal is a Fellow of National Academy of Agricultural Sciences (NAAS). Dr Dadhwal has published 225 peer reviewed journal papers and received many awards including ISRO-ASI award for Space Applications by Astronautical Society of India, ISRO Merit Certificate (2006) for Contributions to application of remote sensing to crop forecasting, Hari Om Ashram Prerit Dr. Vikram Sarabhai Research Award, 1999 for Space Application; Indian National Remote Sensing Award, 1999 of Indian Society of Remote Sensing Dehradun, Young Scientist Medal, 1989 of Indian

National Science Academy, New Delhi and Young Scientist Award, 1987 of Indian Science Congress Association, Calcutta.

Dr. Dadhwal is the editor of Journal of the Indian Society of Remote Sensing and served as the President of Indian National Cartographic Association (INCA) during 2012-13, President of Technical Commission VIII of International Society for Photogrammetry and Remote Sensing (ISPRS) during 2012-2016 and Ex-Officio President (2014-16) of Indian Society of Remote Sensing.

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