ISRO - Genesis and Journey

Dr. B R Nagendra

Space Books Series for Children
U R Rao Satellite Centre
Bengaluru-560017

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Chairman's Message

Scientific literature for children is an essential and distinctive literary work. It is to observe all the happenings around us from a scientific point of view and explain it in simple words. This endeavour can make a high school student understand complex subjects like astronomy, satellite and rocket technology, which is highly appreciable.

In this regard, U R Rao Satellite Centre, a prestigious research Institute in Bengaluru, has launched a new program called "Space Books Series for Children" through which it plans to bring out pocket-books on "Space Technology Space Science and Space Scientists". This book,

which is now in your hands, is one such work. This work a significant step toward enriching science literature for children.

Explaining various scientific and technical topics in simple language is necessary to inculcate interest in science among children. Similarly, it is essential to explain the scientific achievements of our organization to the masses and create awareness about it. The "Space Books Series for Children" programme will fulfil these requirements.

I congratulate the Director of U R Rao Satellite Centre for conceiving and implementing this programme. I hope more topics will be covered and reach more children and commoners in the coming days.

S. Somanath

Chairman, ISRO

Director's Message

Satellite, space science, technology and related topics should be explained in simple language so everyone can easily understand them. Such a literary effort will provide essential and authentic information, especially to the young talents of rural areas. Thus, it is a significant step in providing them with better opportunities and building a great future.

This work should be done by the skilled and experienced scientists of U R Rao Satellite Centre who have been working in this field of technology for five decades. To educate children about space science and technology, U R Rao Satellite Centre is

bringing out the "Space Books Series for Children".

Our enthusiastic colleagues have written books on these topics in response to this idea. It is a pleasure to put seven pocket-books of this series in your hands today. I congratulate the authors for their efforts and wish the program success. I want the students to develop interest and curiosity in these subjects. I also hope they understand the principles, get inspiration and create a better future, thereby contributing to the country's and society's overall development. I am confident that our objective will be realized and the desired result will be achieved.

M Sankaran

Director

U R Rao Satellite Centre

Editorial Board

Space Books Series for Children

Dear Children,

U R Rao Satellite Centre (URSC) celebrated its Golden Jubilee in 2022. On this occasion, the Karnataka Rajyothsava Committee of URSC had taken up the task of publishing a series of Kannada books on Space and Space Scientists which have been translated into English for the benefit of students across the country.

Our committee plans to publish pocket-books in simple language to make school children easily understand many topics like space science, rocket and satellite technology, etc. These books are written by the scientists of our organization. As the first set of books in this series, seven books are published. Our aim is to provide electronic version of the books to children through our website.

Our committee is grateful to Shri M Sankaran, Director, URSC who is the key person behind the successful realization of these books. Our heartfelt thanks to Shri HN Suresh Kumar, Shri KV Govinda, Dr. M Ravindra, Smt. Lalitha Abraham, Smt. Anuradha S Prakasha and Smt. Sreedevi S for having reviewed all seven books in detail and suggested suitable modifications.

We are grateful to all the authors who took time off from their work and authored the books. We are thankful to all colleagues of our Centre who helped us to bring out these books.

If you read them and give your suggestions and comments, we will be able to incorporate the same in the next set of books in this series.

Ramanagouda V Nadagouda

President

Author's Note

U R Rao Satellite Centre is publishing Space Books Series for Children to educate them about the fundamentals of space science and technology. This book in the series tries to introduce ISRO's path of achievements to the children.

The way ISRO was formed, the way it grew, branching into various Centres/Units, the programs undertaken and the services provided to society are briefly explained in this book.

ISRO's achievements, which have established India's fame at the International level, makes all Indians feel proud of this esteemed organization. Satellites built by ISRO, directly or indirectly, are an integral part of every Indian's life.

The goal of this book will be achieved if the interest increases amongst

the children to know more about science, space and satellites.

My heartfelt thanks to Shri. M Sankaran, Director, U. R. Rao Satellite Centre, for giving me an opportunity to write this book. Salutations to Shri Ramanagouda V Nadagouda, Chairman of the Editorial Board of this book series and to all the seniors and colleagues of the organization.

My father, Late Mr. BS Ramachandra Rao and mother Smt. N S Sharadamma are responsible for all that I could achieve in my life. My regards to my wife Smt. T N Yamuna and my son Abhay N Y, who encouraged me to write this book. I am eternally indebted to the love of my sisters Ramamani, Suguna, Suvarna, Sowbhagya, Shailaja and Bhavani, who nurtured and mentored me since my childhood.

Dr. B R Nagendra

Contents

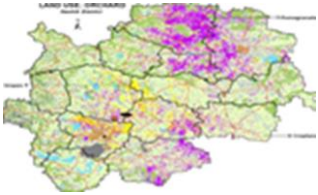
1. Introduction

Can we imagine our life without mobile, TV, GPS, internet etc.? Until twenty or thirty years ago, life went on without these facilities. But, today it is impossible to live without these satellite based services. Governments are also using satellites to provide various services and facilities to improve the quality of life of its citizens.

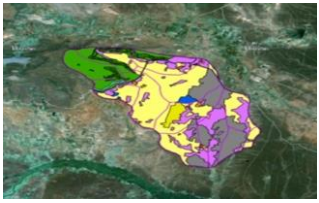
The information obtained from Satellites is being used in a wide variety of areas like agriculture, fisheries, drinking water, waste land management, river water management, forest conservation, weather forecasting, ground water, land resource management, ocean resources, urban development, rural development, search & rescue and disaster management.

Additionally, governments and private organizations are providing various satellite based services to the public in various fields such as tele-medicine, tele-education, TV, telephone, radio, banking, global communication, navigation for land, sea and air transport, and so on. Some of the uses of satellite are shown in Figure-1. Apart from this, research is being carried out in many other domains including the areas of Earth's atmosphere, outer space and universe.

India is one among the few countries in the world involved in space research. The contributions to the space sector by Indian Space Research Organisation, fondly known as ISRO, is a matter of pride for the Indians.



Agriculture



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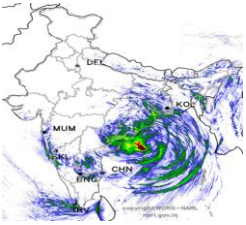
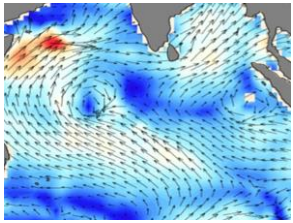


Weather Forecast



Ocean Resources

Tele-education

Tele-medicine

Figure-1: Applications of Satellites

How did man embark on the journey towards space research? When was ISRO formed to carry out space research in India? How did it evolve as a successful organization? What functions are performed by its various Centres? What are the programs, projects, research activities and student outreach programmes that are taken up by ISRO? This book attempts to provide an answer to these questions.

2. Beginning of global space exploration

Since the evolution of mankind, the study of space has been an interesting subject for him. Discoveries in this area started off first with the naked eye, and then with the help of telescopes. When that didn't satisfy him enough, ideas emerged to design instruments for further research.

In this regard, in the year 1896, France sent meteorological instruments using sounding balloons to a height of about 40 km above the earth and carried out experiments on atmosphere and climate. Subsequently, sounding rockets were developed to carry instruments to higher altitudes, in the range of 48 to 145 km. In 1945, America launched the first sounding rocket named Corporal. Research work was also initiated to start developing rockets (also called launch vehicles) to launch artificial satellites to space and place them at even higher altitudes.

The space age began on October 4, 1957, when the then Soviet Russia (USSR) launched the Sputnik-1 satellite, onboard a rocket named Sputnik-BK71PS. The launch of this satellite was the first step towards

revolutionizing human life. In later days, the competition between the United States and Soviet Russia in the field of space research took place at an intense pace.

Yuri Gagarin, the first astronaut to go to space on April 12, 1961, aboard the Vostok-1 spacecraft, has a prominent place in the history of space research. Later, the research and development activities were taken up in an aggressive manner by America and USSR. On July 16, 1969, the United States launched the Apollo 11 spacecraft to the moon using the Saturn V rocket. The astronauts, Neil Armstrong and Buzz Aldrin who were aboard the Lunar Module, stepped on the surface of the Moon after five days of space travel. Meanwhile, another astronaut in the command module, Michael Collins, was

orbiting the moon waiting to bring them back to Earth. The whole world celebrated when the trio returned to Earth safely after eight days on July 24, 1969.

This historic event inspired a few countries of the world to start different space projects through extensive research and development activities. A variety of satellites were manufactured and placed in different orbits of the earth. A number of them have been launched to study the different celestial bodies in the solar system and beyond it. Space research also resulted in technologies that had many other applications for the common man.

India too joined the space travel expedition with Wing Commander Rakesh Sharma becoming India's first astronaut by

travelling to space aboard the Soviet Union's Soyuz T-11 spacecraft for seven days from April 3, 1984. Later, Indian origin astronaut Kalpana Chawla went into space in 1997 and again in 2003. It was unfortunate that while returning to Earth after completing her second space flight, she and all other crew members died in the Space Shuttle Columbia mishap that took place while re-entering the Earth's atmosphere.

Several nations have joined to establish, maintain and operate the International Space Station (ISS) in space, which is continuously orbiting the Earth at an average altitude of 400 km, conducting experiments in space on new technologies that will be useful to mankind. For this purpose, almost every six months,

astronauts from different countries travel to International Space Station(ISS) to replace the crew carrying out research there. As apart of this, Sunita Williams another astronaut of Indian origin, successfully carried out several research activities in ISS for 192 days in 2006 and 126 days in 2012.

Among the several advanced countries like America, Russia, France, England, Germany, Israel, China and Japan involved in space research, India is one of the leading space faring nations. In India, ISRO is the entity carrying out space related research. Let us explore further into the formation and development of ISRO as a successful organization in the field of space research.

3. INCOSPAR

After the launch of Sputnik-1 in 1957 the International Council for Scientific Union took a major decision on space research. In 1958, a Committee on Space Research (commonly referred to as COSPAR) was formed to bring together many countries to jointly carry out space research.

Indian government was keenly monitoring the International developments in space sector. In August 1961, the government entrusted the responsibility of taking up research on Space to Department of Atomic Energy, headed by Dr. Homi Jehangir Bhabha. Realizing the pivotal role of satellites in India's future development, Dr. Homi Bhabha formed INCOSPAR (Indian National Committee on Space Research) on

February 16, 1962 and Dr. Vikram Sarabhai was appointed as its first Chairman.

Dr. Vikram Sarabhai planned to establish a sounding rocket launching facility as the first step in space exploration. Technically, this launch centre needed to be close to the Earth's magnetic equator. A coastal village called “Thumba” near Thiruvananthapuram in Kerala was identified for this purpose. Thumba Equatorial Rocket Launching Station (TERLS) was set up in this village. Initially, TERLS had its office and laboratories in the premises of St. Mary's Magdelene Church and St. Louis School in the village, Thumba. Vikram Sarabhai identified the top brains of the country like Dr. A P J Abdul Kalam, H G S Murthy, C R Satya, R Aravamudan, D Eswar Das, Promod Kale, A S Prakash Rao, B

Ramakrishna Rao, M R Kurup, M G Mathur, S Nambinarayanan, etc. (Figure-2) and convinced them to work at TERLS, paving the way for the future of Indian space research programmes. With the dedicated efforts of all these esteemed scientists under the leadership of Dr. Vikram Sarabhai, TERLS successfully carried out its first launch from “Thumba” on November 21, 1963 by sending the American made two-stage sounding rocket, “Nike Apache” into space. This was the first step towards space research in India and TERLS slowly grew to be the hub of rocket development activities in the later days.

Later, it was INCOSPAR that went on to become Indian Space Research Organization (ISRO) which established itself as the country’s prestigious space agency.

4. Establishment of ISRO

Dr. Vikram Sarabhai and the Government of India clearly believed that India could become a self-reliant nation only when extensive research was carried out in the areas of atomic energy & space, and its benefits reached the common citizen. As these two areas were different and the associated technology, facilities, resource requirements, products and uses were also different, it was decided that both atomic and space research should be handled separately and both should be led by experts in their respective fields. As a result, INCOSPAR, which was conducting space research, metamorphosed into Indian Space Research Organization (ISRO) on August 15, 1969. Initially it started functioning under the Department of

Atomic Energy with Dr. Vikram Sarabhai as the first Chairman of ISRO, along with the additional responsibility of Secretary, Department of Atomic Energy. ISRO's mission was to provide satellite based services to the country and achieve independence in space through innovative technologies.

As space research became extremely crucial for development of the country, the Government of India constituted the Space Commission and the Department of Space in June 1972 and ISRO, which was under the Department of Atomic Energy, was transferred to the Department of Space in September 1972. ISRO continued to work with more determination on several projects to build indigenous launch vehicle and satellites at a rapid pace.

5. ISRO Centres

ISRO has proven its mettle in developing several types of satellites to cater to the wide variety of requirement of the common man, overall development of the country and for space exploration. Launch vehicles of various capacities have been built to launch satellites into space. Various ground stations are established in India and other parts of the world to track and control the satellites once they are placed in Earth's orbit. Several regional units are established in different parts of the country to process and utilize the satellite data for variety of applications. Thus, ISRO has set up several Centres in different parts of the country to support wide range of activities related to space

sector. Let us know about these ISRO Centres located all around India.

5.1 Vikram Sarabhai Space Centre (VSSC)

The Space Science and Technology Centre (SSTC) was established on January 1, 1965 at Veli hills near Thiruvananthapuram, Kerala, with the aim of developing launch vehicles (commonly called rockets) for launching satellites. The aim of the centre was to modernize sounding rockets and develop rockets for launching satellites.

Dr. Vikram Sarabhai, who built ISRO with his great vision for India's future in the field of space, passed away on December 30, 1971. To respect and recognize the contribution of Dr. Sarabhai, in July 1972, TERLS, SSTC and other units were merged

into a single entity named Vikram Sarabhai Space Centre (VSSC). This Centre is presently involved in developing state-of-the-art launch vehicles that launch satellites made by India and other countries. VSSC developed and realized a series of launch vehicles like SLV, ASLV, PSLV and GSLV. The latest in line is a high capacity GSLV Mk-III (LVM3) launch vehicle which can put a 10,000 kg satellite into a low earth orbit and up to 4000 kg satellite in geostationary orbit. Thus starting from sounding rockets to India's flagship LVM3 launch vehicle, VSSC has realized and launched vehicles of different capabilities as shown in Figure-3.

5.2 U R Rao Satellite Centre (URSC)

In 1969, a new division called Satellite Systems Division (SSD) was formed at the SSTC centre in Thiruvananthapuram,

with the aim of developing satellites. On May 11, 1972, this SSD Division was moved to Bengaluru and set up as a separate unit named ISSP headed by Prof. U. R. Rao. ISSP was initially called the Indo-Soviet Satellite Project, and later came to be known as Indian Satellite System Project. Later it was renamed as Indian Scientific Satellite Project.

At the time of its inception, this unit was given a challenging task of developing a satellite within three years.

ISSP team which took up this challenge was completely new to satellite technology. The required infrastructure like building, laboratory, electronic equipment, etc. did not exist at that time. A group of young minds under the leadership of

Figure-2: Dr. Vikram Sarabhai with Dr. A P J Abdul Kalam at ISROLabs

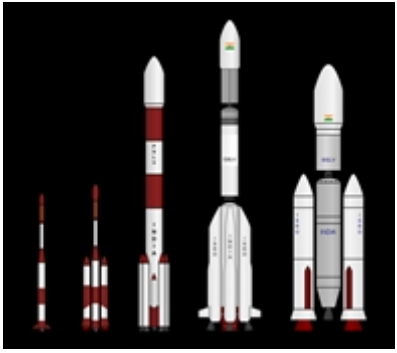


Figure-3: launch vehicle developed by

Figure-4: Prof. U R Rao - Father of Indian Satellite Programme

Figure-5: Few ISRO Satellites

Prof. U. R. Rao (Figure-4) started the complex task of satellite design and development insome sheds at Peenya Industrial Area, Bengaluru. Satellite and its parts were even carried on the shoulders, bicycles and bullock carts during the initial days. Prof. U R Rao started preparing the blueprints for the construction of the laboratories necessary for this research and development work. Thus a small satellite division became a huge organization called ISRO Satellite Centre (ISAC) with state of the art laboratories. In honour of Prof. U R Rao, father of Indian satellite programme, this Centre was renamed as U R Rao Satellite Centre (URSC) on 02-04-2018. Since its inception, more than a hundred satellites have been realized at this centre which are used directly or indirectly by all Indians.

“Aryabhata”, India's first satellite with a mass of 360kg, was successfully launched into space as an experimental satellite on April 19, 1975 aboard the then Soviet Russia's C-1 Intercosmos rocket.

U R Rao Satellite Centre has realized a wide range of satellites from nano-satellites of about 10 kg to heavy satellites of about 6000 kg, with orbits varying from near-Earth orbits to Martian orbits. Over the past 50 years, satellites have been developed at this centre for diverse uses like remote sensing, communication, meteorology, navigation, scientific and interplanetary experiments. (Figure-5).

About forty remote sensing satellites such as BHASKARA, ROHINI, IRS, OCEANSAT, CARTOSAT, RISAT series have

been realized at this Centre. Forty-three satellites of the INSAT and GSAT series of communication satellites have been put into orbit. Nine navigation satellites have been launched to establish India's indigenous navigation system, NavIC. Eight satellites like Chandrayaan 1 and 2, Mangalyaan or Mars Orbiter Mission, ASTROSAT, SROSS, etc., have been sent into space for astronomy and scientific studies. URSC has realized eight experimental satellites, including nano-satellites and mini-satellites. In addition to making more than a hundred satellites, this centre has provided guidance and support to various educational institutions to develop and launch thirteen student satellites on their own. The satellite centre plans to develop

state-of-the-art satellites for variety of applications in the near future too.

5.3 Space Application Centre (SAC)

Every satellite has two types of equipments namely satellite mainframe systems and payloads. The mechanical or electronic systems that are required to operate and maintain a satellite in an orbit are called satellite subsystems. The equipments required to make use of satellites in orbits for variety of applications are called payloads. In order to design and develop various types of Payloads for the satellites, Space Application Centre was formed in 1972 by merging Experimental Satellite Communication Earth Station and other ISRO units at Ahmedabad.

Transponders for communication satellites and various cameras for remote sensing satellites are delivered from this centre. Scientific payload instruments for Chandrayaan and Mangalyaan satellites have also been developed at this centre.

5.4 Laboratory for Electro Optic System (LEOS)

Laboratory for Electro Optic System, commonly known as LEOS, at Peenya Industrial Area Bengaluru, develops optical systems required for the satellites. Very complex and sophisticated mirrors and sensors are being developed in this Unit. Most advanced manufacturing facilities and state-of-the-art laboratories for making optical systems for satellites are set up in LEOS. Using these facilities and labs, optical subsystems such as earth sensors, sun

sensors, star sensors etc. which are called ‘‘eyes’’ of the satellites besides camera payloads for imaging and meteorological applications are being made in this unit. The labs are capable of adopting the next generation technologies and developing the optical systems required for future ISRO projects.

5.5 Liquid Propulsion Systems Centre (LPSC)

Liquid Propulsion Systems Centre(LPSC) is responsible for developing liquid propulsion elements of satellites and launch vehicles. The key propulsion elements include propellant tanks, thrusters, valves and supply systems that supply the fuel to thrusters and engines. This centre has a unit at Valiamala near Thiruvananthapuram for manufacturing

propulsion systems for launch vehicles and another unit in Bengaluru for manufacturing propulsion systems for satellites. As every launch vehicle and satellite requires a propulsion system, this centre has made contribution to all of ISRO's projects. In addition to this, transducers and sensors are also being developed in this Centre to estimate the amount of available fuel in the tanks.

5.6 ISRO Propulsion Complex (IPRC)

ISRO Propulsion Complex (IPRC) is located at Mahendragiri, Tamil Nadu. Separated from its parent organization, the Liquid Propulsion Systems Centre in 2014, this Unit carries out research for the development of liquid propulsion systems both for satellite and launch vehicles. This Unit has the state of the art facilities for

assembly, integration and testing of liquid propulsion systems. IPRC has played a major role in development of the indigenous cryogenic engines needed to launch heavy communications satellites into geostationary orbit. IPRC has the responsibility of delivering the second and fourth stages of the PSLV launch vehicle, commonly referred to as ISRO's workhorse.

5.7 ISRO Inertial Systems Unit (IISU)

ISRO Inertial Systems Unit (IISU) is established in Thiruvananthapuram, Kerala. Inertial systems such as mechanical and optical gyros, momentum and reaction wheels, solar array drive assembly, etc. required for all satellites and launch vehicles are manufactured in this Unit. These systems ensure that the satellites remain in a predefined orbit. Actuators and

mechanisms of International standards are being manufactured in this Unit. Advanced manufacturing techniques are used to make these inertial systems.

5.8 Satish Dhawan Space Centre (SDSC)

ISRO decided to establish a launch pad in India with the objective of not having to depend on foreign countries for launching Indian satellites. Detailed study was carried out on the requirement of a rocket launching centre. The eastern coast was found to be suitable for India's satellite launching centre. Sriharikota, an island in Nellore district of Andhra Pradesh, near Sulurpet, between the Bay of Bengal and the Pulicat Lakes, was identified as an ideal location. This location was close to the equator and was suitable for launching vehicles towards the east. Thus the

Sriharikota High Altitude Range Rocket Launch Centre, also known as SHAR Centre, was established. This Centre was formally commissioned and dedicated to the country on October 09, 1971 with the launch of a Rohini-125 sounding rocket. On September 05, 2002, SHAR centre was renamed as Satish Dhawan Space Centre in the memory of Prof. Satish Dhawan, former Chairman of ISRO. This launch centre has two launching pads. Remote sensing satellites and most of the communication satellites built by ISRO are launched from this Centre. India's flagship satellites Chandrayaan-1, Chandrayaan-2, and Mangalyaan were also launched from this Centre. Apart from this, satellites of many other countries have been launched from this Centre. This Centre has also created an unprecedented record

in February 2017, by launching 104 satellites from different countries with PSLV-C37. SDSC provides world class launch infrastructure for national and International customers in launching satellite missions for remote sensing, communication, navigation and scientific purposes. It is also involved in realizing initial stages of launch vehicles called solid rocket boosters and testing solid rocket motors.

Figure-6: Launch Pad at SDSC

5.9 ISRO Telemetry Tracking and Command Network (ISTRAC)

Once a satellite is launched and placed in an orbit around the Earth, the control centre at ground station will be communicating with it. The act of continuously observing the satellite is called tracking. A variety of information needs to be obtained from different subsystems of the satellite to confirm that it is in healthy condition. This information about health of the satellite is called telemetry data. It is also required to give instructions through commands to operate different sub systems of the satellites from control centre. This function is carried out by telecommand system. ISTRAC's function is to track remote sensing satellites in space, get their

telemetry data and send appropriate commands. To control the remote sensing satellites of India, ISTRAC has established control centres at Bengaluru, Lucknow, Sriharikota, Port Blair, Thiruvananthapuram, Mauritius, Brunei, Indonesia etc. ISTRAC has also established Indian Deep Space Network at Byalalu, Bangalore, which consists of 18-m and 32-m antennae, which are essential for tracking satellites during interplanetary missions.

5.10 Master Control Facility (MCF)

To track ISRO's geostationary satellites, receive their telemetry data and issue necessary telecommands to control them, the control centres are setup at Master Control Facility (MCF) at Hassan in Karnataka and Bhopal in Madhya Pradesh. These Centres continuously track and

control India's communication and navigation satellites and obtain necessary information from them. In addition to tracking and controlling these satellites, the control centre operates payload systems as per user requirements while the satellites are in orbit.

5.11 National Remote Sensing Centre (NRSC)

Remote sensing satellites take images of different parts of the Earth from the space in different wavelengths and send them to Earth. The information obtained from these images will be useful to farmers, fishermen and various departments of the government. Acquiring the data from satellites and processing it in a suitable manner and making them useful is the task of the National Remote Sensing Centre

(NRSC) at Hyderabad, Telangana. Regional Remote Sensing Centres (RRSC) have been set up in most of the states in India for processing the satellite data/images as required by various organizations of that region and providing information for the development of those regions.

5.12 Indian Institute of Remote Sensing (IIRS)

Analysing satellite images is not an easy task. It requires vast knowledge about classification, analysis and processing of remote sensing images. Training scientists in this regard is the objective of Indian Institute of Remote Sensing (IIRS), Dehradun, Uttarakhand, in collaboration with Space Science and Technology Centre of United Nations.

This institute is offering several training programs related to processing of satellite images. Appropriate curriculum has been devised for different levels of young scientists, graduates and researchers.

5.13 Developmental and Educational Communication Unit (DECU)

The objective of Developmental and Educational Communication Unit (DECU), Ahmedabad, Gujarat is to make Indian satellites, specially communication satellites useful to common man. The mission of this centre is to implement projects like tele-education, tele-medicine for the benefit of students and society. The Centre has undertaken projects to convey through appropriate multimedia how Indians can benefit from ISRO's activities.

6. ISRO's Achievements

Indian space research led by Dr. Vikram Sarabhai, started in 1962 under Department of Atomic Energy, which was then headed by Dr. Homi Jehangir Bhabha. Later considering the importance of space research for development of modern India, a separate entity called Indian Space Research Organization was established on 15-08-1969. Later, Department of Space was formed on 01-06-1972 and all space related activities were handed over to this department.

Dr. Vikram Sarabhai, Prof. M G K Menon, Prof. Satish Dhawan, Prof. U R Rao, Dr. K Kasturirangan, Shri. Madhavan Nair, Dr. K Radhakrishnan, Shri A S Kiran Kumar, Dr. K Sivan and presently Shri. S Somanath, as Chairman of ISRO, have contributed to

establishing its unique work culture. ISRO's achievements under their leadership are extraordinary. From the launch of India's first successful satellite Aryabhata on 19-04-1975 to the recent successful launch of the EOS-06 satellite on 26-11-2022, ISRO's achievements are immense and ISRO has become the pride of all Indians.

Following the path laid by Dr. Sarabhai, ISRO has successfully designed, developed and dedicated to the country, several types of satellites and the launch vehicles that carry them into space. In this modern age, satellite is essential for every aspect of our life. Satellites are essential for TV, telephone, remote sensing, weather forecasting, communication, navigation, defence, etc. Apart from this, ISRO also undertakes space research and

interplanetary missions. Different satellites are made to cater to different requirements for different uses and missions. Note worthy among them are the INSAT and GSAT satellites for communication, remote sensing satellites like IRS, RESOURCESAT, CARTOSAT etc. for national development, ASTROSAT satellite for astronomy purposes, CHANDRAYAAN and MARS ORBITER MISSION satellites for the study of Moon and Mars, etc.

Launch vehicles which are commonly called as rockets of various capacities are developed by ISRO for launching the satellites into its pre-decided orbits. ISRO has developed various launch vehicles starting from SLV (Satellite Launch Vehicle), ASLV (Augmented Satellite Launch Vehicle), PSLV (Polar Satellite Launch

Vehicle), GSLV (Geostationary Satellite Launch Vehicle), etc. Earlier, ISRO had to depend upon America, Europe and Russia to launch the Indian satellites. Now, ISRO is launching satellites of different countries of the world.

SLV was the first rocket developed by ISRO to launch satellites. Its weight was about 17 ton, and height of about 22 meter. It had a capability of launching satellites of 40 kg into space. Research and development in the area of launch vehicles has led ISRO to realizing a high-capacity rocket, GSLV Mk III, also known as ISRO's Baahubali, which is 640-ton, 43.43meter-tall. It can place satellites of 4000kg into geostationary orbit and satellites of mass 10000 kg into near-Earth orbit.

ISRO, which has recorded many achievements in space domain, is encouraging the private industry to manufacture all the components required for launch vehicle and satellite in India, in order to make India completely self-reliant in the space sector in the near future.

7. ISRO and Students

All centres of ISRO are conducting various programs to educate the students, teachers and general public about space technology and successful projects undertaken by ISRO. ISRO hopes that students will learn more about space science, increase their interest in this area, get involved in space research, make India completely self-reliant in the space technology in the future. The mission is to

make India stand among the advanced countries of the world in space research.

In this regard, ISRO instituted several programs and projects to inculcate interest in space science and technology among students and motivate talented students to conduct research in this field. Now let's know about all these outreach programmes in detail.

7.1 Indian Institute of Space Science and Technology (IIST)

In order to make India fully independent in the area of space technology in the future, it has planned to identify talented students from different parts of the country and give them special education in the space domain. For this purpose, ISRO has established Indian

Institute of Space Science and Technology, near Thiruvananthapuram, Kerala. Students from all corners of the country take up B.Tech., M. Tech. and doctoral programmes in the niche field of space science at this institute. This institute aims to produce the best space scientists of the future.

7.2 Student satellites

Inspired by ISRO, students of several educational institutes in India, have built nano-satellites. ISRO is constantly providing guidance and necessary support to these students and institutions. ANUSAT, STUDENTSAT, SRMSAT, JUGNU, SATYABHAMASAT, SWAYAMSAT, PISAT, PRATHAM, NIUSAT, KALAMSAT-V2, UNITISAT, SATISHDHAVANSAT, etc. which are the satellites made by students have been launched into space by ISRO.

7.3 Visits to ISRO Centres by students

Students across the country visit various ISRO Centres as part of their educational tour. During these visits, ISRO scientists enlighten students on satellite and rocket technologies. Students are also given an opportunity to see ISRO in action at various laboratories.

7.4 Programs of National Science Day

As part of the National Science Day which is celebrated on February 28 every year, ISRO Centres organize several programs to encourage scientific thinking among students. Thousands of students participate in various activities conducted on this occasion.

7.5 Student-Scientist Interaction

On the occasion of important celebrations like World Space Week, Centenary celebrations of Space Scientists, Swachh Bharat Programmes, etc., ISRO scientists visit schools, especially in rural areas and explain space technology to children in very simple local language and infuse interest in science and space in the young minds. A set of mobile exhibition vehicles called Space on Wheels has been designed for this purpose. These vehicles travel across the country to introduce students to space technology.

7.6 UNNATI Program

In order to inspire developing countries in the world to take up space projects, ISRO has not only trained young men and women of different countries in satellite construction but also provided

hands-on training to them to make and test nano-satellites themselves. Many countries of the world have appreciated ISRO and Indian government for this initiative.

7.7 YUVIKA Programme

To inculcate interest in space technology among the young minds of India, a set of high school students are given specialized training in space science at various ISRO centres. This program is conducted to identify and train future scientists of the country.

Thus, ISRO has instituted several programs to train future space scientists. One such program is to publish the books for students in English, Hindi and various other Indian languages. The objective of these student outreach programmes is to

ensure that India will have enthusiastic young scientists to lead the country's space sector in the future.

8. Conclusion

ISRO’s achievements are a source of pride for all Indians. The mission of this organization is to utilize the technology available from space research for the development of India. ISRO's aim is to develop satellites and launch vehicles that will benefit the common man of the country. Undoubtedly, it can be said that ISRO is on the path of achievement by realizing several satellite/launch vehicle projects and auxiliary technologies for remote sensing, communication, navigation, meteorological, space science research, and many more applications.

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