CHAPTER III
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SPACE RESEARCH INSTITUTIONS IN INDIA

The Indian space programme was institutionalized in 1962 with the setting up of Indian National Committee for Space Research (INCOSPAR) and it began the work on Thumba Equatorial Rocket Launching Station (TERLS), near Thiruvananthapuram.¹ Space research was initially allocated to the Department of Atomic Energy (DAE) in August 1961. In the following year INCOSPAR was setup by DAE, and in 1969, INCOSPAR was reconstituted² under the Indian National Science Academy and a new organization, Indian Space Research Organization (ISRO), was formed under the DAE. The national space programme was formally organized in June 1972 with the setting up of Space Commission and the Department of Space (DoS) the Indian Space Research Organisation (ISRO) to promote the development and application of space technology and space science for the socioeconomic benefit of the nation.

Department of Space implements the policies framed by the Space Commission. Research and development activities are carried out through the ISRO, the National Remote Sensing Agency (NRSA), the Physical Research Laboratory

(PRL), the National Mesosphere–Stratosphere–Troposphere Radar Facility (NMRF) and other agencies for specific programme. The two main national space systems that have been established. The Indian National Satellite (INSAT) system and National Natural Resources Management System (NNRMS) – are coordinated and managed by the secretary-level INSAT Coordination Committee (ICC) and the planning committee of NNRMS (PC-NNRMS) respectively. These committees provide guidelines for evaluation of the systems and also oversee the progress. NNRMS Standing Committees (NNRMS-SC), which are set up with user ministries and departments, ensure an efficient and coordinated functioning of different NNRMS elements. An Advisory Committee on Space Sciences (ADCOS) guides the research programmes in the area of space sciences. The Antrix Corporation Limited, Bangalore, established in 1992, is a company owned by the Government of India and plays the role of commercially marketing space products and services.

If Indian space programme is widespread with all these organizations, the entire credit goes to Dr Vikram Sarabhai. Sarabhai is aptly called the father of Indian Space Programme. This is attributed to his unparalleled contribution to Indian space programme in his short span of life, particularly his initiative in founding ISRO and various other organizations. During the 1950s and 1960s, the world countries

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5 Available at www.antrix.org.
expected India to concentrate on various imminent issues that pose threat to the very existence of the vast country, which one can comprehend to be natural because the country has just achieved independence. Integrating the country itself was a major task. Then there were issues of providing the people with basic needs such as food, shelter, and clothes and other necessities of providing education, addressing unemployment and poverty alleviation. No one even dreamt of India entering into space programme, which needs sophisticated advances in science and technology and huge amounts of money.

In spite of all these, a few believed that India should enter into space programme. They believed 'the development of a nation was closely linked with a good understanding of science and the sound application of it in the form of technology'. Most important of them were Jawaharlal Nehru, Indira Gandhi, Vikram Sarabhai, and Homi Jahangir Bhabha. Sarabhai rightly observes:

There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the explorations of the moon or the planets or manned space flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to

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none in the applications of advanced technologies to the problems of man and society which we find in our country

Forty years after he made the above speech, India in fact has leapfrogged in its way to development.7

Dr. VIKRAM SARABHAI (1919–1971)

Vikram Sarabhai was born on 12 August 1919 in the city of Ahmedabad in Gujarat. The Sarabhai family was an important and rich business family. His father Ambalal Sarabhai was an affluent industrialist who owned many mills in Gujarat. Vikram Sarabhai was one of the eight children of Ambalal and Sarala Devi. Sarabhai matriculated from the Gujarat College in Ahmedabad after passing the Intermediate Science examination. After that he moved to England and joined the St. John’s College in 1940. With the outbreak of the Second World War, Sarabhai returned to India and joined the Indian Institute of Science in Bangalore and began research in cosmic rays under the guidance of Sir C.V. Raman, a Nobel Laureate. He returned to Cambridge after the War and was awarded a Ph.D in 1947 for his thesis entitled “Cosmic Ray Investigation in Tropical Latitudes”.8 In the mean time Sarabhai began to work on cosmic ray intensity variations, which later led him directly into studies of

7 ISRO Seminar on Indian Programme for Space Research & Application, Ahmedabad, August 7-12, 1972, (Bangalore: ISRO, August 1972), p.X-1.
interplanetary space, solar-terrestrial relationships and geomagnetism. His first scientific contribution, "Time Distribution of Cosmic Ray", is published in the proceedings of the Indian Academy of Science in 1942.9

Marriage and Children

In September 1942, Vikram Sarabhai married Pagalalla Mote, a celebrated classical dancer of India named Mrinalini. The wedding was held in Chennai without anyone from Vikram's side of the family attending the wedding ceremony because of the ongoing Quit India Movement led by Mahatma Gandhi. Vikram and Mrinalini had two children -- Karthikeya and Mallika. Mallika Sarabhai is also a renowned dancer.10

Institution Builder

After receiving Ph.D from Cambridge University in 1947 he came to India. Looking at the needs of the country, he persuaded charitable trusts controlled by his family and friends to endow a research institution near his home in Ahmedabad. On 11 November 1947, the Physical Research Laboratory (PRL) was founded in Ahmedabad. He was only twenty-eight at that time. Sarabhai was a creator and

10 Available at www.hinduonnet.com.
cultivator of institutions and PRL was the first step in that direction. Now the PRL is supported by the Department of Space (DoS). The Physical Research Laboratory, in 1955, set up a research station at Gulmarg in Kashmir for the measurement of cosmic ray intensities as well as atmospheric ozone and night air glow. The successful functioning of this station and the important scientific results obtained there encouraged the Department of Atomic Energy to setup a full-fledged High Altitude Research Laboratory at Gulmarg in 1963, thus fulfilling one of Dr. Sarabhai's long-cherished plans. Dr. Sarabhai realized very early that earth-based studies of cosmic ray time-variations of extraterrestrial origin would open up a new window on outer space. He therefore pursued these studies with great patience, energy and enthusiasm. He set up outstations of the PRL at Kodaikanal and Thiruvananthapuram to continue these investigations, and also strove continuously to increase and extend the accuracy of observations by setting up super-neutron monitors and large area scintillation telescopes to improve the statistics. This chain of cosmic ray stations has been yielding valuable data and, since the first International Geophysical Year (1957–8), has been an important part of a global network.

Apart from this valuable effort Sarabhai founded various institutions such as the Ahmedabad Textile Industry's Research Association (ATIRA), in Ahmedabad in

13 Ibid., pp.53-54.
1947; the Suhrid Geigy Limited, in Baroda in 1955; the Ahmedabad Management Association in 1957; Sarabhai Merck Limited, Baroda (now called Sarabhai M. Chemicals) in 1955; Sarabhai Research Centre and the Operations Research Group, in Borada in 1960; the Symbiotics Group and the Sarabhai Glass in Baroda, in 1961; the Indian Institute of Management (IIM), Ahmedabad, Nehru Foundation for Development, the Community Science Centre in 1966; and the Electronics Corporation of India Limited (ECIL) in 1967 at Hyderabad. He also set up Uranium Corporation of India Ltd in Jaduguda in 1967.\(^{14}\)

Contribution to the Space Research

Sarabhai's active interest and involvement in space science and in the technologies connected with it began in 1940 when he joined the Indian Institute of Science, Bangalore, to work under Professor C.V. Raman. On the advice of Professor Raman, he chose “Time Variations of Cosmic Rays” as the subject for his doctoral work. When Sarabhai was working in Bangalore, Dr. H.J. Bhaba was also in the Indian Institute of Science, working on theoretical problems of nuclear physics and organizing experimental studies of cosmic rays with balloon-borne equipment and radio telemetry. Sarabhai's work on cosmic rays during the period 1940–5 included the study of the time variations of cosmic rays.\(^{15}\) In his scientific work at the PRL, Dr. Sarabhai set himself the problem of finding the meaning of the small time—

\(^{15}\) Available at www.hinduonnet.com.
variations of very high energy particles (mesons and neutrons) constituting the cosmic rays which come to the earth from space, from outside the solar system. Systematic monitoring of cosmic rays from different directions was started at Ahmedabad, using narrow-angle telescopes and the anisotropy of cosmic rays with respect to local solar time was established. Monitoring stations were also established at Kodaikanal, Thiruvananthapuram, and Gulmarg. A new era in space research started on the 4 October 1957, when the USSR positioned its first earth-orbiting satellite, Sputnik, and the USA followed shortly after. They proved that artificial, radio transmitting and receiving stations could be set up not only anywhere on the surface of the earth but also in outer space.\textsuperscript{16} After this development Government of India took meaningful and constructive efforts towards the space programme. The first step was setting up of INCOSPAR (Indian National Committee for Space Research) with Sarabhai as chairman.\textsuperscript{17}

These circumstances provided congenial climate for the space programme. Sarabhai made some important steps to promote Indian space programme. In this connection first and foremost step was the establishment of Thumba Equatorial Rocket Launching Station in 1963. Thumba is a fishing coastal village near Thiruvananthapuram. Sarabhai selected this place for sounding rocket because of the atmosphere and outer space over low latitudes and, in particular, over the magnetic

equator. Subsequently the first sounding rocket Nike Apache provided by NASA with a sodium vapour payload provided by CNES, France, was launched on 21 November 1963. At the initial days lack of facilities in Thumba had shocked all the scientists. However, the team made very effective contribution to the development of sounding rocket research in Thumba, thanks to the effective leadership and constructive steps taken by Sarabhai. Between 1961 and 1966, a number of organizations were built up under the guidance of Dr. Sarabhai. The Physical Research Laboratory, Ahmedabad, was expanded as headquarters for space administration and as a space science centre for developing techniques and scientific payloads for rockets to be launched from Thumba. A Space Science and Technology Centre (SSTC) was setup near TERLS in Thumba and work started on rocket materials, propellants, fabrication of rockets, testing systems etc. Arrangements were made with Sud Aviation, France, to make, under license, the two-stage Centaur Rocket in India. In the mean time the UN General Assembly gave recognition to TERLS as an international facility, three years after the formal dedication of TERLS to the UN took place in February 1968. After Dr. Bhaba's lamented death in January 1966, Dr. Vikram Sarabhai was asked in May 1966 to take over

21 Available at www.hinduonnet.com.
responsibilities as chairman of the Atomic Energy Commission and Secretary of the Department of Atomic Energy. Soon after, he wrote to the prime minister as follows:

- Currently I have substantive responsibilities in three areas. First at the Physical Research Laboratory as director and professor of cosmic ray physics, where I continue my research and the supervision of doctoral candidates. Second, as Chairman of the Indian National Committee for Space Research and as a person administratively in-charge of the space research programme as well as the project for the development of rockets and space technology. Thirdly, I have been concerned with policy making, operations research, planning and evaluation of a significant segment of the family business interests, primarily centered round chemicals and pharmaceuticals. While I have great job satisfaction in my present work, I am attracted by the opportunity for taking over the work which was started by Dr. Bhaba. The task of pushing ahead with the application of science and technology for the needs of the nation under your leadership is an inspiring one, which I am happy to shoulder, accepting full responsibility.\(^\text{23}\)

Vikram Sarabhai was made overall in-charge of both atomic energy and space research in India from May 1966 till the last minute of his life. In the field of atomic

energy, he continued and extended the pace-setting programme of Dr Bhabha, expanding the advanced research activities of the TIFR and BARC and expediting the construction of the reactor stations at Tarapore, Ranapratapsagar, and Kalpakkam. Another important step was taken by Sarabhai, with the cooperation of the Andhra Pradesh government, a second rocket fabrication and launching station was organized at Sriharikota on the Bay of Bengal.24

Dr. Sarabhai was elected the scientist-chairman of the UN conference of the exploration and peaceful uses of outer space which was held in Vienna in August 1968, in which he discussed the significance of space research for developing nations and possible uses of geostationary satellites for national and international communications and for television for the education of the rural population of large countries.25 Shortly after this, Indian Space Research Organization was set up by the government with Dr. Sarabhai as chairman. A space applications centre was established at Ahmedabad with a number of technical divisions. The most important of the planned applications was the creation of facilities for a Satellite Instructional Television Experiment (SITE).26 Besides this Sarabhai was honoured with several awards, such as the S.S. Bhatnagar medal for his scientific research in physics in 1962, the Padma Bhushan in 1966 and was presented a profile for the decade 1970–80 for

the atomic energy and space research programme for India. In 1962 he presided over the Physics section of Indian Science Congress held in Cuttack and he was a convener of Pugwash conference held in Udaipur in 1964. He was also the president of the 14th General Conference, conducted by International Atomic Energy Agency (IAEA), held in Vienna in 1970. In the year 1972, he was awarded Padma Vibhushan posthumously.

Vikram Sarabhai passed away at the young age of fifty-two on 30th December 1971 at Kovalam, Thiruvananthapuram. The sudden demise of Sarabhai created a vacuum in the space research in India. But the institutions slowly recovered from the painful death of Sarabhai with the help of his effective successors Satish Dhawan, U.R. Rao, and Kasthurirangan. However, the place of Vikram Sarabhai in Indian Space programme is ever revered.

Indian National Committee for Space Research (INCOSPAR)

INCOSPAR was established in the year 1962. It functions under the Indian National Science Academy (INSA), which is the national adhering organisation to the International Council of Scientific Unions (ICSU) and is a member of ICSU. INCOSPAR has the following terms of reference:

(i) to promote international cooperation in space research and in the peaceful uses of outer space;
(ii) to liaise with the Committee on Space Research (COSPAR) of ICSU and generally to encourage and support international activities likely to contribute to the peaceful uses of outer space.\textsuperscript{27}

Department of Space

Department of Space (DoS) and the Space Commission were established in June 1972 and brought ISRO under DoS in September 1972. Its secretariat is in Bangalore and is one of the departments directly functioning under the prime minister of India.\textsuperscript{28} ISRO is an integral part of India’s DoS. Coordination between ISRO and other space-related departments is carried out at the political level through the Indian Space Commission (ISC), which reports to the prime minister’s office. The ISC director is also the head of the DoS and the Chairperson of ISRO. The ISC formulates Indian space policy and the DoS executes ISC policy through ISRO.\textsuperscript{29} The Space Commission, the apex body, mainly formulates policies and oversees the programme to promote the development and application of space science and technology for the socio-economic benefit of the country.\textsuperscript{30} Under the DoS the following institution are functioning: the ISRO, the National Natural Resources Management System (NNRMS), the National Remote Sensing Agency (NRSA), the


Physical Research Laboratory (PRL), and the National Mesosphere Stratosphere Troposphere Radar Facility (NMRF). Under ISRO, organizations such as Vikram Sarabhai Space Centre (VSSC), Sriharikota Rocket Range (SHAR), Information Sharing and Analysis Centre (ISAC), Space Application Centre (SAO), Liquid Propulsion Systems Centre (LPSC), ISRO Inertial Systems Unit (IISU), ISRO Telemetry Tracking and Command Network (ISTRAC), Master Control Facility (MCF) and the Development and Educational Communication Unit (DECU) are functioning. Regional Remote Sensing Service Centre comes under the - National Natural Resources Management System (NNRMS).\(^{31}\)

**National Natural Resources Management System**

Recognizing the need and importance of natural resources management in the country, Government of India has set up the National Natural Resources Management System (NNRMS). NNRMS is an integrated approach for the management of natural resources, optimally utilising the advantages of conventional systems and the information derived through remote sensing. DoS is the nodal department in Government of India for the evolution and establishment of NNRMS and all remote sensing-related activities. With a view to have optimum use of space technology for national development it was felt necessary to create facilities for...

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analyzing remote sensing data to derive planning related inputs on natural resources of our country.\footnote{32}

The NNRMS umbrella includes a large cross-section of government departments/agencies who are responsible for resources management sectorally and other agencies associated in developmental activities. Department of Space provides the secretariat support to NNRMS and also is the focal agency for supporting the NNRMS activities. As part of NNRMS, the Indian Remote Sensing programme aims at an integrated development of an end-to-end capacity for the optimum utilisation of the technology, specifically to address national priorities. The Indian Remote Sensing Satellites are an important element of the NNRMS. And serve a national goal in terms of providing continuous, operational remote sensing data services for the management of the natural resources of the country. A series of remote sensing Satellites, have been providing remote sensing data services on a continuous basis to the users. The data from IRS are used for applications in the areas of agriculture, hydrology, geology, drought and flood monitoring, marine studies, snow studies and land use and thus is central towards the establishment of NNRMS.\footnote{33}

The planning committee of NNRMS (PC-NNRMS) provides guidelines for implementation of the system and oversees the remote sensing applications.\footnote{32 \textit{Government of India, Department of Space, Annual Report, 2005-2006}, (Bangalore: ISRO, 1998), p.14.} \footnote{33 J. Krishnamurthy (et.al.,), \textit{Loc cit.}}
Standing Committees have been constituted for application of remote sensing in different thematic areas. They are (i) Agriculture and Soils, (ii) Bio-Resources, (iii) Geology and Mineral resources, (iv) Water Resources, (v) Ocean Resources, (vi) Cartography and mapping, (vii) Urban Management, (viii) Rural Development, (ix) Meteorology and, (x) Training and Technology. Each of these Standing Committees is chaired by secretary of the respective government departments and includes experts from major user department agencies. The Remote Sensing application projects at national, regional and local levels are carried out through NRSA, Hyderabad, SAC, Ahmedabad, five Regional Remote Sensing Application Centres (RRSSC) located at Jodhpur (western region), Dehradun (north-central region), Kharagpur (eastern region), Nagpur (central region) and Bangalore (southern region) and North-Eastern Space Application Centre (NE-SAC), Shillong. These Centers are strategically located. State and Central government departments, state remote sensing centres and others are associated in these projects. Towards this, DoS has established five Regional Remote Sensing Services Centres (RRSSCs) in the country for speedy operationalisation of remote sensing as an integral component of natural resources inventory, monitoring and management. In addition, twenty-three states have setup state Remote Sensing Application Centres. As a result, the State Centres are able to conduct application projects of relevance to their states and also

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participate in various national projects. RRSSCs enable the use of remote sensing technology at a reasonable cost to derive necessary information on various aspects related to natural resources. RRSSCs participate actively in areas like disaster management, software development, agro-climatic planning, national drinking water mission, national resources census, large-scale mapping, and so on, besides taking up projects for various ministries and departments.

Besides, RRSSC also carries out projects in areas like resources mapping/inventory and monitoring; land and water resources development planning; urban and regional planning; infrastructure planning; command area management; disaster management; integrated studies; environmental impact analysis; change detection; digital cartographic database; site suitability assessment; crop area assessment; coastal/marine applications; urban environmental studies; and value added services.

Research and development efforts are going on in areas such as assessment of horticulture crops, onion crop estimation, solid waste management, cadastral level applications, and top map update and chlorophyll estimation.

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37 Available at http://isro.org/about-isro.htm.
National Remote Sensing Agency

National Remote Sensing Agency (NRSA) is an autonomous registered society, mainly supported by DoS located at Hyderabad. NRSA has a strong operational disaster support programme for mapping and monitoring floods, cyclones, drought, landslides, earthquake, forest fires, etc. The agency is responsible for acquisition, processing, and distribution of data aerial remote sensing and decision support for disaster management. It has satellite earth station at Shadnagar, near Hyderabad, for receiving data from IRS satellites, United States’s LANDSAT and NOAA, France’s SPOT and microwave data from the European Remote Sensing Satellite (ERS). NRSA utilises modern remote sensing techniques for assisting in the planning and management of the country’s natural resources and provides operational support to various users. Indian Institute of Remote Sensing at Dehradun conducts training courses in remote sensing for user agency personnel at different levels and functions under NRSA.

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41 Available at http://www.isro.org/decade_plan.htm.
Physical Research Laboratory

Physical Research Laboratory (PRL) at Ahmedabad is an autonomous institution established in 1948 by Vikram Sarabhai. In 1960–61, it was decided by the Government of India that the PRL be made an autonomous research institution under the trusteeship and management of the Government of India, the Government of Gujarat, the Karmakshetra Educational Foundation and the Ahmedabad Education Society. Later, it came under DoS (established in 1972) and largely funded through grants-in-aid from DoS. It is a premier institute for multidisciplinary research in astronomy and astrophysics, earth sciences, planetary sciences, space sciences and basic sciences including high energy physics, nuclear physics, atomic and molecular physics, quantum optics and quantum information. It is also entrusted with the management of the Udaipur Solar Observatory (USO). PRL has extensive academic programme for doctoral and post-doctoral research. Vikram Sarabhai, who was responsible for setting up of PRL, established out stations of the PRL at Kodaikanal, Thiruvananthapuram and Gulmarg in Kashmir to continue cosmic rays investigations.

Atmospheric Research Laboratory

Atmospheric Research Laboratory (NARL) at Gadanki near Tirupati is an autonomous society supported by DoS. It is a premier centre for atmospheric research with facilities like mesosphere–stratosphere–troposphere radar, LIDAR, lower atmospheric wind profiler, disdrometer, optical rain gauge and automatic weather station along with associated facilities. NARL is available for national and international scientists to conduct research.49

North Eastern-Space Applications Centre

NE-SAC is located at Shilling, the capital city of Meghalaya state in the North-East India. It is a joint initiative of DoS and North Eastern council to provide development support to the North Eastern region using space science and technology. The centre has the mandate to develop high technology infrastructure support to enable north-eastern states to adopt space technology inputs for their development.50

Semi-Conductor Laboratory

Semi-Conductor Complex Limited, Chandigarh, a public sector undertaking under the Department of Information Technology (DIT) has come under the administrative control of DoS in March 2005. DoS has undertaken re-structuring of

SCL into an R&D society. The society, named Semi-Conductor Laboratory, has been registered in November 2005. SCL is entrusted with the design and development of Very Large Scale Integration (VLSI) devices and development of systems for telecommunication and space sectors. SCL has facilities for fabrication of micro-electronic devices in 0.8-micron range and Micro Electro Mechanical Systems (MEMS). Actions to upgrade the facilities to fabricate advanced devices in 0.35-micron range have been initiated.51

**Antrix Corporation Limited**

The commercial aspect of India's space program has become prominent in the 1990s, when, influenced by India's economic liberalization program, ISRO's goals have widened to include offering its space services on the international market. The Antrix Corporation was set up in 1992 to serve as the marketing arm of India's space agency52 and is located in Bangalore. The word *antrix* is derived from the Sanskrit *Antariksha* means "space". The main aim of Antrix is the promotion and commercial exploration of products and services from the Indian space programme.53 Antrix markets subsystems and components for satellites, undertakes contracts for satellites to user specifications, provides launch services and tracking facilities, and organizes

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training of manpower and software development. As ISRO's commercial wing, Antrix Corporation Ltd has contracts with the American company EOSAT, allowing the latter to market IRS imageries worldwide outside the Indian footprint area comprising India and its neighbouring countries. It has agreements with several countries for providing access to IRS data in real time, including Germany, Japan, Australia, and Thailand.

**Indian Space Research Organisation**

Indian Space Research Organization was established in 1969 under DAE, with its headquarters in Bangalore. ISRO is responsible for the execution of the space programme of the Government of India and for promoting research and development in this field. The Indian space programme is directed towards the goal of self-reliant use of space technology for national development, and its main thrusts areas are:

1. satellite communication for various national use
2. satellite remote sensing for resource survey and management, environmental monitoring and meteorological services, and

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56 Dinshaw Mistry, *Loc.cit.*, 
(iii) development and operationalization of indigenous satellite and launch vehicles for providing these space services.\textsuperscript{57}

ISRO is the sponsoring agency for participation of Indian scientists in collaborative space research programmes with foreign space agencies. Also, through the RESPOND (research sponsored by ISRO) programme, ISRO provides support to universities and other academic institutions in the country for research and development projects in specific areas relevant to India’s space programme.\textsuperscript{58}

The overall coordination of the space programme is carried out by programme offices of ISRO headquarters in different areas like satellite communication, earth observation systems, launch vehicle programme, space science, technology transfer and industry coordination, international cooperation, publications and public relations and budget and economic analysis.\textsuperscript{59}

\textbf{Vikram Sarabhai Space Centre}

In 1963, Thumba Equatorial Rocket Launching Station (TERLS) was founded and the first sounding rocket (Nike Apache) was launched from here.\textsuperscript{60} Thumba

\textsuperscript{58} \textit{Ibid.}
\textsuperscript{60} Pushpa Mittra Bhargava, \textit{Op.cit.}, 94.
Equatorial Rocket Launching Station successfully launched hundreds of sounding rockets subsequently and was dedicated to the United Nations on 2 February 1968.61

In 1965 the Space Science and Technology Centre was established. The whole complex at Thumba, which included TERLS, the Space Science and Technology Centre (SSTC), the RPP, the Rocket Fabrication Facility (RFF), and the Propellant Fuel Complex (PFC) were merged together to form an integrated Space Centre and christened the Vikram Sarabhai Space Centre (VSSC) as a tribute to the man to whom it owed its existence.62 Vikram Sarabhai Space Centre is ISRO's largest centre.63 The VSSC is primarily concerned with the development of various technologies for launch vehicles. The different R&D groups of VSSC are aeronautics, avionics, composites, computer and information, control, guidance and simulation, launch vehicle design, mechanical engineering, mechanisms, vehicle integration and testing, propellants, polymers, chemicals and materials, propulsion, propellants and space ordnance, and systems reliability, programme planning and evaluation, technology transfer and industrial coordination. Human resources development, safety and personnel and general administration groups support the centre.64 The research and test facilities are located, mainly, in Thumba and Valiamala, in

Thiruvananthapuram. The composite development activities are carried out at Vattiyoorkavu in Thiruvananthapuram. An ammonium perchlorate experimental plant has been set up at Aluva. The Space Physics Laboratory, located at Thumba, carries out research in atmospheric and related space sciences. The major projects managed by VSSC are satellite launching vehicle (SLV), augmented satellite launch vehicle (ASLV), polar satellite launch vehicle (PSLV), the geosynchronous satellite launching vehicle (GSLV) and the Rohini sounding rocket (RSR) programme. VSSC has various mechanical, chemical, and electronics facilities for development, production, and testing to meet the needs of the on-going programmes.

Satish Dhawan Space Centre, Sriharikota Rocket Range

Satish Dhawan Space Centre (SDSC), of Sriharikota Rocket Range (SHAR), is India’s primary space launch centre, situated at Sriharikota Island on the east coast of Andhra Pradesh, 80 kilometre from north Chennai over the Bay of Bengal. It operates ISRO’s principal rocket and satellite launching range which is in use since 1971. Major launching vehicles including SLV, ASLV, PSLV, and GSLV were launched from here. For the first time, the state-of-the-art second launch pad (SLP) at SDSC was used for a launch on 5 May 2005. The centre includes ISRO range computer (IREX), solid propellant space booster plant (SPROB), SHAR computer

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67 Available at www.astronautix.com.  
facility (SCOF), programme planning and evaluation group (PPEG), SHAR central
design (SCEND), Reliability and Quality Assurance Group (REQA) and Sriharikota
Common Facilities (SCF).  

The centre has facilities for processing solid propellant motors required for
launch vehicles and their ground testing. The activities in the range operations
comprise mission analysis and range safety, programme management, computer
facilities, meteorology, and range instrumentation. The solid propellant space booster
plant processes solid propellants. The other two main components of the centre are
(i) the liquid propellant storage and service facilities and (ii) vehicle assembly and
static test facilities. Quality and reliability group as well as the programme planning
and evaluation group provide necessary support to the centre. Sriharikota Common
Facilities (SCF) looks after engineering maintenance transport, fire services, medical
and public health and so on.  

This centre was renamed Satish Dhawan Space Centre on 5 September 2002, in
memory of the eminent space scientist Prof. Satish Dhawan, who passed away on 3
January 2002. Satish Dhawan was an Indian rocket scientist who was born on 25
September 1920, in Srinagar, and studied in India and the United States. He

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graduated from the University of Punjab (Lahore) with an unusual combination of degrees: a BA in Mathematics and Physics, an MA in English Literature, and a BE in Mechanical Engineering. In 1947 he obtained an MS in Aeronautical Engineering from the University of Minnesota and moved to the California Institute of Technology, where he was awarded the aeronautical engineer's degree in 1949 and a Ph.D in Aeronautics and Mathematics in 1951 with the eminent aerospace scientist and fluid dynamist Prof. Hans W. Liepmann (Honorary Fellow of the Academy) as adviser. After he had completed his Ph.D, he came to India and joined as a senior scientific officer at the Indian Institute of Science (IISc) in 1951, where he became professor and head of the department of aeronautical engineering in 1955 and became director in 1962. At IISc, he built the first supersonic tunnels in the country. He was the father of experimental fluid dynamics research in India, and indeed was in many ways the first engineering scientist of the country.

In 1972 Prof. Dhawan was appointed as chairman of the space commission and of the Indian Space Research Organization, and secretary to the Government of India in DoS. It was an inspiring appointment. The Indian space programme owes its birth to the vision of Vikram Sarabhai, but the excellent technology development in the organization was because of Dhawan's creation. In the decade following his

72 Available at www.iisc.ernet.in/nisa/sdewan.htm.
appointment, he directed the Indian space programme through a period of extraordinary growth and spectacular achievement. Major programmes were carefully crafted and systematically executed, including the first Indian satellite Aryabhatta, which was launched from Soviet cosmodrome in 1975, followed by satellites such as Bhaskara in 1979, and APPLE in 1981. The starting of INSAT programme in 1982 was highly noteworthy.\textsuperscript{75} Besides this, Indian space programme achieved a landmark event (the launching of SLV indigenously) was the launching vehicles from Sriharikota island, which put Rohini satellite into orbit.\textsuperscript{76} With this India became the sixth nation to possess launching vehicles technology and also become one of the members in the space club. Pioneering experiments were carried out in rural education, remote sensing, and satellite communications, and led to operational systems like INSAT, which became (and continue to be) a part of Indian life.

Under the directorship of National Aeronautical Laboratory (NAL, now called the National Aerospace Laboratories) during 1984–93, his students express how much they benefited by his advice and friendly criticism much more importantly from his gentle but unceasing pressure on them to promote civil aviation.\textsuperscript{77} Prof. Dhawan persistently took efforts for the promotion of Indian space programme even after he officially left ISRO in 1984. He wrote \textit{Bird flight}, a book published by the Indian Academy of Sciences. In 1997 his articles, papers, and lectures were compiled and

\textsuperscript{75} Anitha Bhatia, \textit{Loc.cit.}
\textsuperscript{77} Available at www.issc.ernet.in/nias/sdhawan.htm.
published by ISRO, Bangalore,\textsuperscript{78} which contains very valuable information about the space research; it is not only a source book for the scientists but also a knowledge-treasure to the public. Dhawan received several honours: the Padma Vibhushan in 1981; Indira Gandhi Award for National Integration in 1999; the Distinguished Alumnus Award, Indian Institute of Science; and the Distinguished Alumnus Award, California Institute of Technology in 1969. Among his numerous awards, one that deserves special mention is the Indira Gandhi Award for National integration, bestowed on him in 1999 with a citation that read, in part: "The award goes fittingly to one of our foremost scientists, teachers, and national builders, Prof. Satish Dhawan, who has made multidimensional contributions to scientific education, research, policy formulation and implementation and is deeply concerned with the solution of national problems through the use of science".\textsuperscript{79}

Recognizing Dhawan’s invaluable contribution to Indian Space Research, the Government of India renamed Sriharikota Rocket Launching Station as Satish Dhawan Rocket Launching Station in 2002 soon after his death. Satish Dhawan specially distinguished from many other eminent scientists and engineers through his extraordinary qualities as a leader and a human being, his great personal charm, and his keen social conscience. His contribution will ever be remembered as long as India continues to hold its place in the space science. On his demise, former prime minister

\textsuperscript{78} \textit{Prof. S. Dhawan’s Articles, Papers, and Lectures, (November 1966 to December 1994)}, (Bangalore: ISRO, 1997), p.32.
\textsuperscript{79} Available at www.iisc.ernet.in/nias/sdhan.htm.
of India Atal Bihari Vajpayee praised the role of Satish Dhawan in the Indian space research and his versatile quality:

His unique human qualities, combining intense personal charm with a deep commitment to social values and an extraordinary objectivity in management, led several generations of students, colleagues and administrators to efforts that, perhaps, would not have been undertaken otherwise.80

ISRO Satellite Centre

ISRO Satellite Centre (ISAC) is the leading centre for developing satellite technology and implementation of satellite systems for various scientific, technological, and applications missions located in Bangalore.81 Aryabhatta, Bhaskara, APPLE, and INSAT series of satellites were built here.82 The centre is functionally organized into five R&D divisions:

1. mechanical systems area covering structures, thermal systems and spacecraft mechanisms
2. digital and communications area covering digital system and communication systems

3. integration and power area covering system integration, spacecraft checkout and power systems
4. controls and mission area covering control systems mission development and computer and information and facilities
5. reliability and components area covering indigenization and components and systems reliability.\textsuperscript{83}

Computer group, programme planning and evaluation group, space astronomy and instrumentation division support the activities of the centre.\textsuperscript{84}

Laboratory for electro-optic systems (LEOS) at Bangalore working under the overall umbrella of ISAC carries out R\&D in the field of electro-optics sensors required for satellites. ISRO Radar Development Unit (ISRAD) at Bangalore, also working under the overall umbrella of ISAC, carries out R\&D in the area of radar systems needed for space programme such as tracking radars, wind profile radar and weather radars needed for meteorological applications.\textsuperscript{85} Achievements of ISAC include design and development of twenty-three satellites so far of various types like scientific, communication and remote sensing. INSAT-2E, IRS-P4, IRS-P5, IRS-P6, and G-SAT are its ongoing projects.

\textsuperscript{85} \textit{SAC Courier}, Vol.23, No.1., (January, 1998), p.3.
Space Applications Centre

Space Application Centre (SAC) came into being in 1972 and is located at Ahmedabad in Gujarat. The primary tasks of SAC are to conceptualize, plan, and execute projects and to conduct research leading to practical applications of space technology. The centre has two main areas of R&D, namely satellite-based communications, TV and remote sensing for natural resources survey and management, environmental monitoring, meteorology and geodesy. These programmes are executed by four main functional areas/groups and their supporting facilities, namely, communications area, remote sensing area, planning and projects group, and software systems group. The centre has set up facilities for mechanical fabrication, electronic fabrication including microwave integrated circuits, spacecraft payload fabrication, and environmental tests. It has also a reliability and quality assurance group and programme planning and project groups. SAC is responsible for the operation of Delhi Earth Station (DES) for satellite communications.

Liquid Propulsion Systems Centre

Liquid Propulsion Systems Centre (LPSC) is responsible for the development of the liquid and cryogenic propulsion stages in PSLV and GSLV. LPSC is gaining

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86 Ibid.
greater importance as liquid engines are being introduced in India’s main orbital launchers and with the increasing size of indigenous satellites.\textsuperscript{90} The activities are spread across three units located at Thiruvananthapuram, Mahendragiri and Bangalore. LPSC at Thiruvananthapuram carries out design and system engineering to earth-storable and cryogenic engine, stages for launch vehicles, design and development of bipropellant thrusters and electric propulsion thrusters for spacecraft, control components and control systems. LPSC, Mahendragiri, carries out assembly and integration and testing of earth-storable and cryogenic engines and stages, high-altitude testing of upper stage engine and spacecraft thrusters, as well as testing of subsystems\textsuperscript{91}. This centre also has facilities for storage of earth-storable and cryogenic propellant including integrated liquid hydrogen plant. LPSC at Bangalore carries out design, development, and testing of propulsion systems for spacecraft, spacecraft propellant plant and so on. It also carries out transducer design and development.\textsuperscript{92}

**ISRO Inertial Systems Unit**

ISRO Inertial Systems Unit (IISU), Thiruvananthapuram, carries out R&D programmes related to inertial sensors and systems required by satellites and launch vehicles. IISU is organized into R&D divisions in the fields of navigation systems,

\begin{itemize}
    \item \textsuperscript{90} R.L.N.Sharma, \textit{Loc.cit}.
    \item \textsuperscript{92} Government of India, Department of Space, Annual Report, 2005-2006, (Bangalore: ISRO, 1998), p.15
\end{itemize}
satellite inertial systems, bearing and space tribology and inertial systems integration and simulation. Facilities fabrication assembly, integration and testing have also been established. Its achievements are development of inertial systems for ISRO launch vehicles and satellites, solar array drive assemblies, scanning mechanisms, and so on.

ISRO Telemetry, Tracking, and Command Network

The ISRO Telemetry Tracking and Command Network (ISTRAC), with its headquarters at Bangalore, operates a network of ground stations to provide tracking, telemetry, and command (TTC) support for launch vehicles and satellite missions of ISRO. ISTRAC has the prime responsibility to provide mission support to near-earth satellites and launch vehicle missions. It has a network of ground stations at Bangalore, Lucknow, Sriharikota, Port Blair and Thiruvananthapuram in India. Besides these stations, ISTRAC has TTC stations at Mauritius, Bears Lake (Russia), Biak (Indonesia) and Brunei. A multi-mission spacecraft control centre is located at Bangalore. The various activities of ISTRAC are organized into network operations, network augmentation, mission operation and spacecraft health monitoring, communications and computers and control centre facilities, and development projects. Programme planning and reliability groups support the ISTRAC activities.

ISTRAC also operates the Local User Terminal/Mission Control Centre

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94 Available at http://www.isro.org/about_isro.htm.
97 Available at http://www.isro.org/about_isro.htm.
(LUT/MCC) under the international programme for satellite-aided search and rescue.98

**INSAT Master Control Facility**

The INSAT Master Control Facility (MCF) at Hassan in Karnataka was established during 1980–8199 for post-launch operations on INSAT satellites including orbit manoeuvres, station keeping and on-orbit operation of the spacecraft.100 MCF-Hassan has the overall radio visibility coverage from Persian Gulf in the west to Australia in the east (of about 150° of the geo-arc). The geographical advantage, together with a low radio noise environment, made MCF-Hassan ideal for controlling the geostationary satellites positioned over Asia-Pacific region.101 INSAT MCF closely interacts with users’ agencies for payload operations, setting transponder gains, planning eclipse load shedding station keeping manoeuvres and undertakes recovery procedures in case of loss of lock.102 The MCF is an integrated facility consisting of five satellite control earth stations with associated electronics and spacecraft control centre for carrying out the satellite control operations.

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102 *Space India*, Loc. cit.
To meet the future demand, a second master controlling station was set up at Bhopal, the capital city of Madhya Pradesh on 11 April 2005. MCF-Bhopal helps MCF-Hassan to support the operational requirements of an increasing number of satellites in INSAT system. MCF-Bhopal offers the same radio visibility coverage advantage as MCF-Hassan. It consists of a satellite control earth station and power computer. Special operations like station-keeping, management of eclipse operations and payload operations to suit the requirements of INSAT users is being carried out from the new MCF Bhopal facility. The location of MCF-Bhopal has enabled in-orbit testing of satellites, especially for their spot beam coverage.\footnote{Geo view, Vol.2, Issue.1, (January-March, 2003), pp.3-4.}

**Development and Educational Communication Unit**

Development and Educational Communication Unit (DECU) at Ahmedabad is involved in the conception, definition, planning, implementation and socio-economic evaluation of innovative configuration for space applications.\footnote{Satish Tiwari, Op.cit., pp.11-12.} The role of DECU within the overall ambit of the Indian space programme is summarised as below:

1. studying societal needs and projecting future needs that will serve as inputs to the planning of space applications system
2. conceiving space applications programmes to meet social needs
3. planning policy studies for experimental and operational space applications programmes
4. organizing, catalysing, and demonstrating projects for new applications of space and related technologies for a variety of end-users of socio-technical systems

5. studying social, economic, and cultural impact of new technologies

6. designing systems strategies for appropriate "software"

7. producing suitable "software" as models/examples

In short, DECU "end links" from the people to the people.  

The major activities of DECU

The major activities of DECU includes EDUSAT pilot projects, implementation and utilisation; GRAMSAT programme including pilot projects in different states and Training and Development Communication Channel (TDCC). Village Resources Centres (VRC), telemedicine, science channel and new satellite communication development and applications.

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105 Available at http://www.isro.org/about-isro.htm.