Indian Space Research Organisation
Department of Space
Government of India

CONTENTS

Historical notes

1961- Space research and the peaceful uses of outer space was entrusted to the Department of Atomic Energy (DAE) by the Government of India.

1962- DAE set up Indian National Committee for Space Research (INCOSPAR) to advise and organise India's space programme.

1969- INCOSPAR was reconstituted as an advisory body under the Indian National Science Academy, and the Indian Space Research Organisation (ISRO) was set up under DAE to conduct programmes of space research and their utilisation for peaceful purposes.

1972- The Government of India set up the Space Commission and the Department of Space (DOS), and entrusted DOS with the responsibility for conducting India's space programme. ISRO functions under DOS as its research and development organisation.

Chairman, INCOSPAR

1962 - 1971 Prof. V. A. Sarabhai

During 1972 Prof. M. G. K. Menon

From 1973 Prof. S. Dhawan

Chairman, ISRO

1969 to Dec. 1971 Prof. V. A. Sarabhai

Jan. to Sept. 1972 Prof. M. G. K. Menon

From Sept. 1972 Prof. S. Dhawan

"...The Indian space programme has crossed an important milestone. Our plans of using space science and technology for national tasks are now nearer to being translated into reality...ISRO can now look forward to accomplishing further tasks in harnessing space for the service of the nation...."

Thus remarked Prof. S. Dhawan, Chairman, ISRO, on the occassion of the successful launch of Aryabhata, India's first satellite, in 1975. Aryabhata has now been orbiting the earth for more than two years.

During 1975-76, 2,400 television sets, specially designed by ISRO, were installed in as many villages and received for a year national-development-oriented TV programmes direct from a geostationary satellite. This experiment was known as the Satellite Instructional Television Experiment (SITE). Aryabhata and SITE are but two of the important results of India's space programme.

Space technology has now been gainfully used in many areas such as agriculture, communication, weather forecast, mineral exploration and resources survey. And it was the extensive scope for the application of space technology in a developing country which prompted India to launch its space programme.

Any technology can be utilised to the maximum extent only when a country develops indigenous competence in it. Right from the beginning the aim of ISRO has, therefore, been to develop and master space technology and establish research and development facilities for this purpose.

ORGANISATION

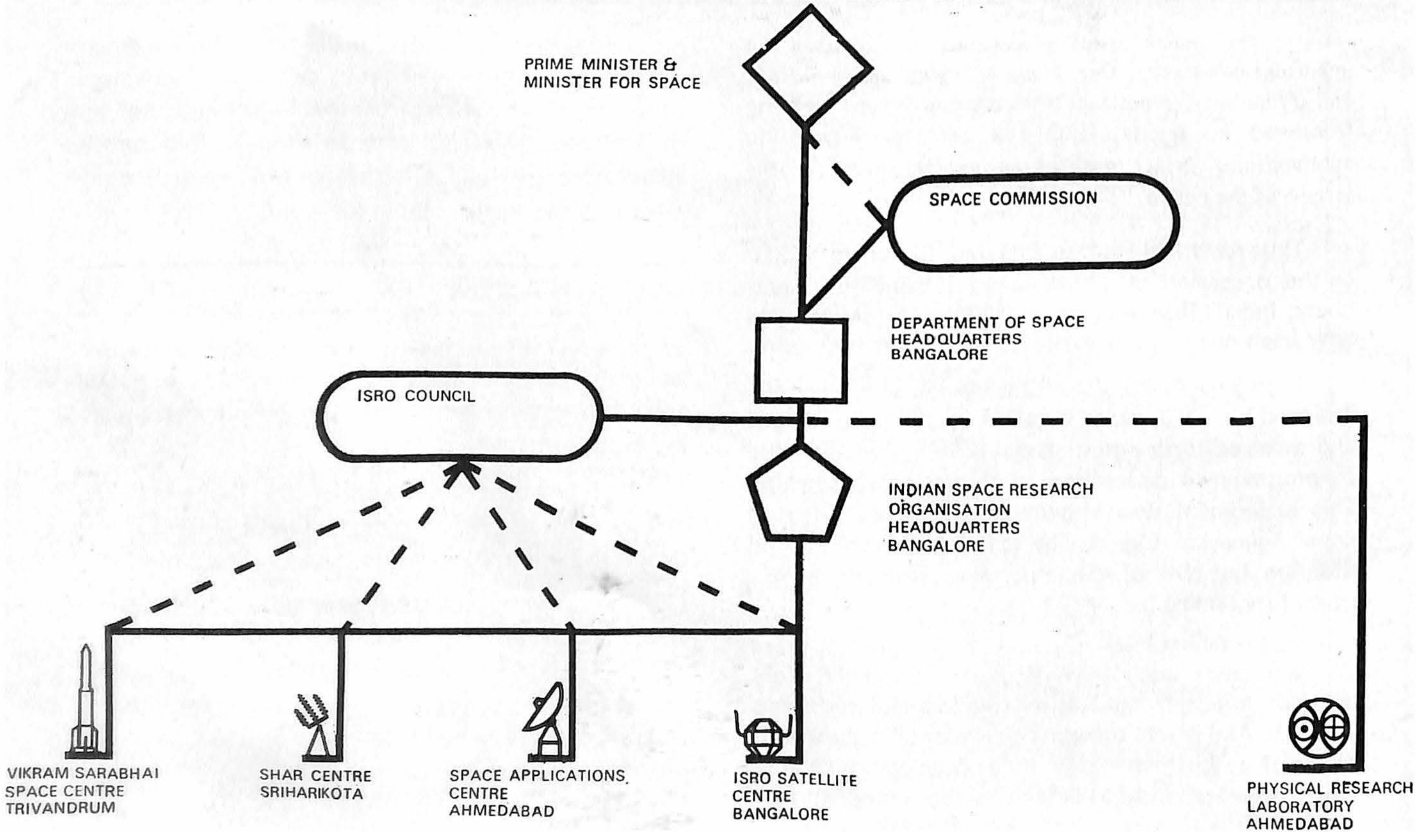
The Space Commission is responsible for formulating the policy of the Department of Space (DOS) and advising the Government of India in matters relating to space.

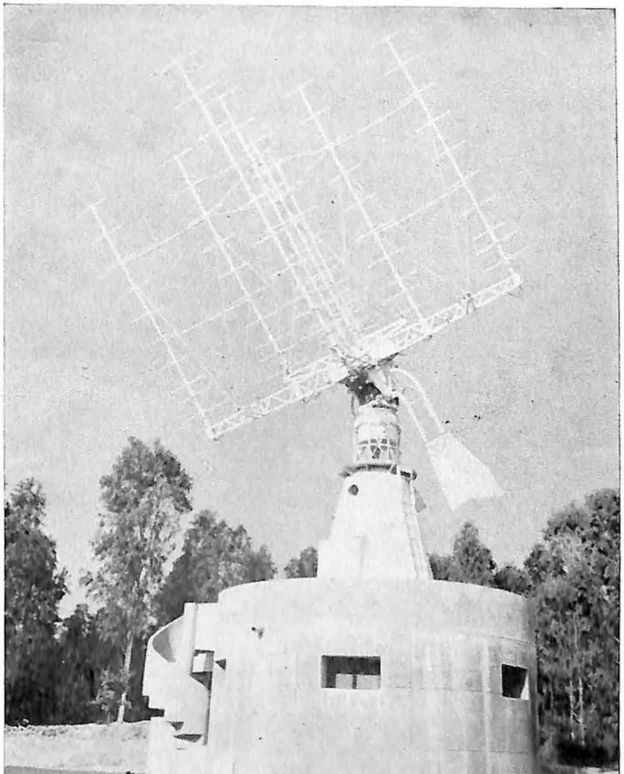
DOS functions directly under the Prime Minister. The Secretary to the Government of India in DOS is also Chairman, Space Commission, and Chairman of ISRO.

The activities of ISRO, with its headquarters at Bangalore, are carried out at its four Space Centres :

- Vikram Sarabhai Space Centre (VSSC), Trivandrum, Kerala.
- ISRO Satellite Centre (ISAC), Bangalore, Karnataka.

GOVERNMENT OF INDIA • DEPARTMENT OF SPACE • INDIAN SPACE RESEARCH ORGANISATION





- SHAR Centre in the Sriharikota island of Andhra Pradesh.
- Space Applications Centre (SAC), Ahmedabad, Gujarat.

In addition, DOS provides major support to the Physical Research Laboratory (PRL) at Ahmedabad which is India's prime centre for research in space sciences.

Vikram Sarabhai Space Centre (VSSC)

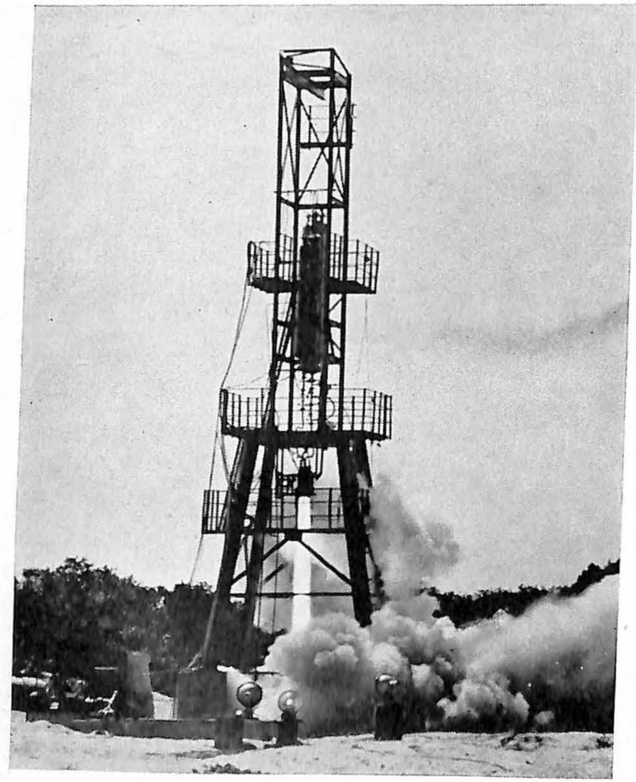
Named after the late Prof. Vikram A. Sarabhai, the founder of the Indian space programme, VSSC is the main centre for research and development in space technology. This encompasses all aspects of work related to the development of sounding rockets and satellite launch vehicles, scientific and technological payloads, ground-based and vehicle-borne instrumentation and production facilities for propellants and rocket hardware. VSSC is developing the Menaka and Rohini series of sounding rockets and a satellite launch vehicle called SLV-3.

◁ **Telemetry antenna at SHAR Centre**

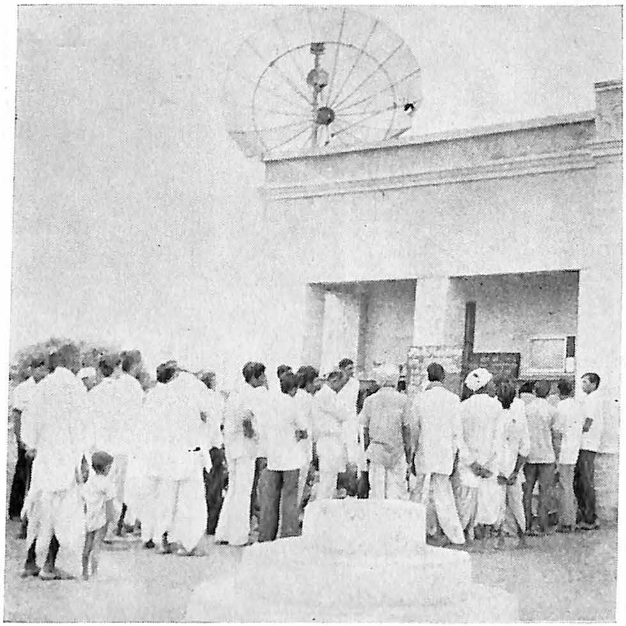
The sounding rocket launching range of this Centre, the Thumba Equatorial Rocket Launching Station (TERLS), is situated on the west coast close to the magnetic equator. The location of TERLS offers unique advantages for the study of low-latitude upper atmospheric and ionospheric phenomena which are of special importance in the magnetic equatorial region. The United Nations Organisation has recognised this range as an international facility for sounding rocket experiments. Since November 1963, when the range became operational, more than 500 sounding rockets of different makes have been launched for meteorological, ionospheric, aeronomic and astronomical studies. Scientists from France, Federal Republic of Germany, Japan, UK, USA and USSR have participated, in cooperation with their Indian counterparts, in many of these experiments.

ISRO Satellite Centre (ISAC)

ISAC is the main research and development laboratory of ISRO for satellite technology. It helps in planning and executing ISRO's satellite missions. The



Liquid propellant rocket motor test stand ▷



Villagers watching SITE programme

first Indian satellite, Aryabhata, was designed and fabricated by this Centre. Currently it is engaged in the fabrication of two more satellites—the Satellite for Earth Observations (SEO) and the Rohini Satellite (RS-1). This Centre is also responsible for building India's experimental geosynchronous communication satellite called APPLE (Ariane Passenger Palyoad Experiment) to be launched by an Ariane test flight of the European Space Agency in 1980.

SHAR Centre

This Centre in the Sriharikota island, off India's east coast, is about 100 km north of Madras City. It is being developed as a range for launching large multistage sounding rockets and satellite launch vehicles. Facilities to launch sounding rockets up to 560 mm in diameter have been established and these are being expanded for launching larger and heavier rockets. The augmented facilities will be used for flight-testing different stage combinations of SLV-3.

A satellite launch complex, along with supporting facilities, is being established and is expected to be ready soon for the flight-tests of SLV-3. Facilities have also been set up for the production of propellants and static tests of rocket motors.

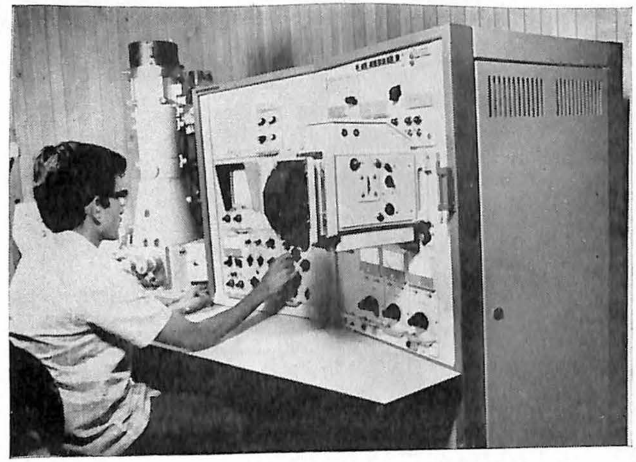
The main ground station for Aryabhata is located at this Centre. It will also serve as the prime mission control centre for India's second satellite, SEO, and all future spacecraft launched by ISRO.

Space Applications Centre (SAC)

Developments in space science and technology can be used to help solve many problems facing a country like India with a vast population and large natural resources still to be utilised. The objective of the Space Applications Centre is to apply space science and technology to practical uses. To achieve this goal SAC has taken up work in :

- Telecommunication and television broadcasting and reception via satellites
- Use of remote sensing techniques to survey natural and renewable earth resources
- Studies in space meteorology and satellite geodesy.

This Centre is developing expertise as well as instrumentation required in these application areas.

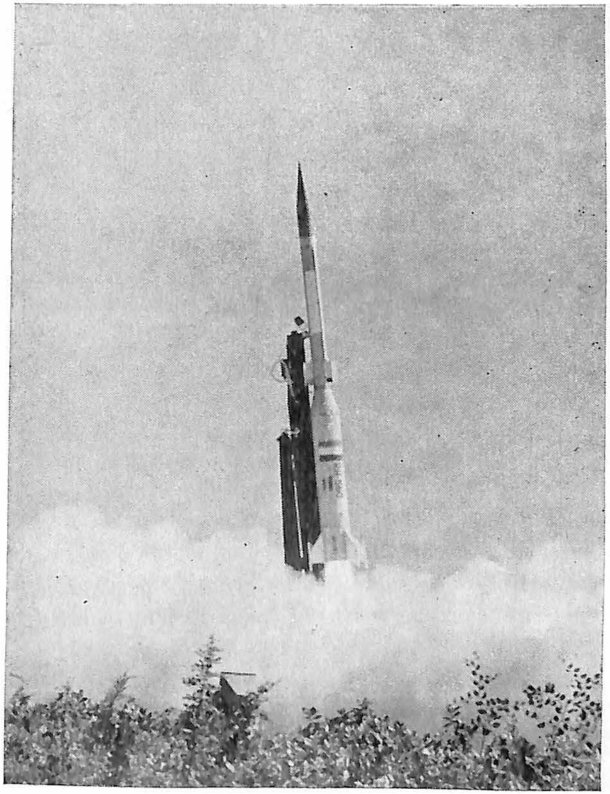


Scanning electron microscope at PRL

Recently it successfully conducted SITE, the year-long (August 1975 to July 1976) experiment in direct broadcast of television programmes via the NASA satellite, ATS-6.

Physical Research Laboratory (PRL)

This laboratory has been the pioneer in space science research in India. It is being developed



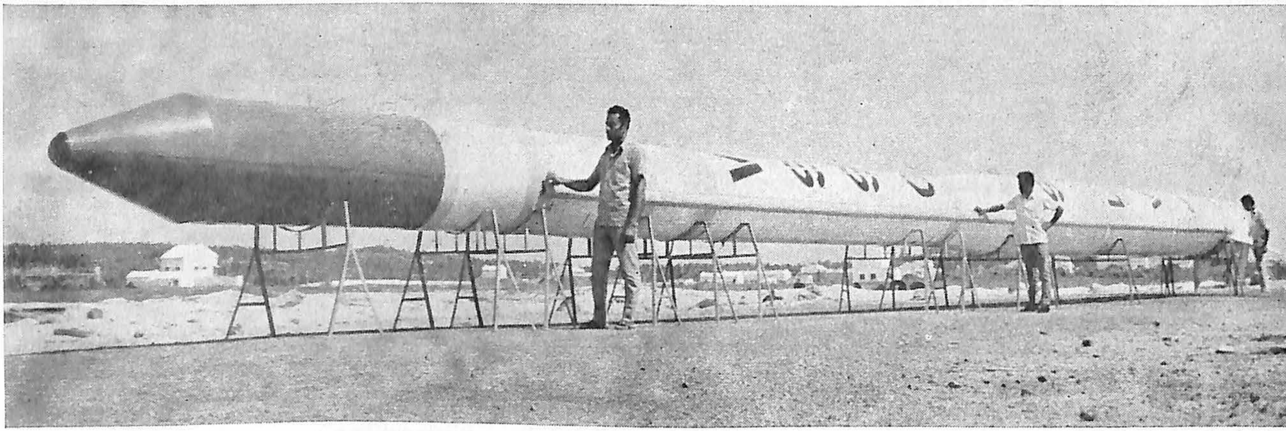
further as a national centre in this field. Its activities are supported mainly by DOS. PRL conducts basic research in many areas of space sciences for understanding the structure and dynamics of the earth's upper atmosphere, the solar terrestrial relationship and astrophysical problems. For these studies, data are collected through laboratory experiments, ground-based observations and measurements with rocket-borne instruments. PRL scientists participate in many rocket-borne experiments at TERLS. They also use the data received from various orbiting scientific satellites of other countries. Investigations using lunar samples and meteorites, and laboratory studies of plasma for understanding certain ionospheric phenomena and astrophysical problems are also conducted here. Climatological and hydrological studies are also undertaken.

MAJOR PROGRAMMES

Sounding rockets and launch vehicles

VSSC has developed the Menaka series of rockets for meteorological sounding and the Rohini series of rockets (including the Indian Centaure rocket) for

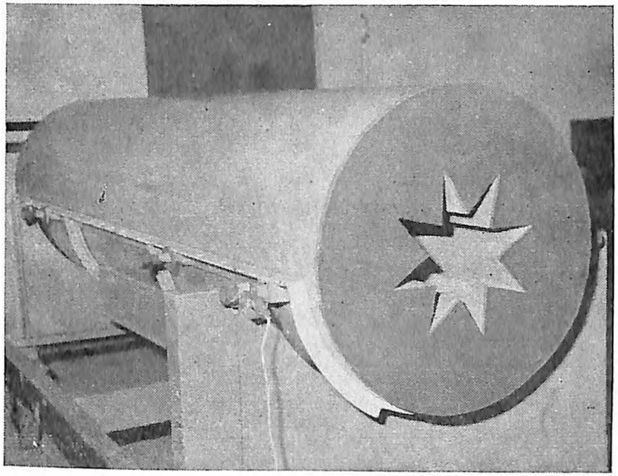
◁ RH-560 rocket lifting off from SHAR Centre



A full size model of SLV-3

scientific investigations of the upper atmosphere. Menaka-II is used for collecting information on meteorological parameters such as temperature, wind speed and direction. Rohini and Centaure rockets are used for experiments to study the characteristics of different ionospheric layers, the equatorial electrojet which passes over Thumba region at an altitude of about 100 km, properties of the neutral upper atmosphere, X-ray astronomy, etc. Scientists from PRL, the Tata Institute of Fundamental Research in Bombay, the National Physical Laboratory in New Delhi, the Gujarat University in Ahmedabad and the Indian Institute of Science in Bangalore participate in the rocket-borne experiments at TERLS. Some of these experiments are conducted at the SHAR range also.

Under the Satellite Launch Vehicle (SLV-3) Project, VSSC is developing a four-stage solid-propellant rocket for launching a 40-kg satellite called Rohini into an elliptical earth orbit of 300 km



RH-560 propellant grain

perigee and 885 km apogee. SLV-3 will be about 23 metres in length and its maximum diameter will be one metre. More than 46 public and private sector industries and educational institutions in the country are participating in the development of hardware and software for this project. A launch vehicle involves the development of many subsystems like rocket motors for different stages and their propellants, interstages, stage separation mechanism, heat shield, control and guidance instruments and vehicle electronics. The first Rohini Satellite (RS-1) is designed to monitor the performance of the fourth stage of SLV-3 which will inject the satellite into orbit. It will also monitor the parameters of injection (such as altitude, injection angle and velocity), orbital path after injection and the housekeeping data of the satellite itself while in orbit. The flight testing and launching of SLV-3 will be conducted from the satellite launching range at SHAR Centre and the first sub-orbital flight test is expected to take place in late 1977.

Solid propellants for the Menaka and Rohini series of sounding rockets and SLV-3 have been developed at VSSC and facilities for their production have been established. Most of the ingredients of these propellants are produced at VSSC.

In the field of liquid propellant rockets, the development of a three-tonne thrust liquid engine is underway and the rocket will be flight-tested soon. On-the-job training of ISRO engineers is in progress for acquiring know-how and technology related to high-thrust liquid engines.

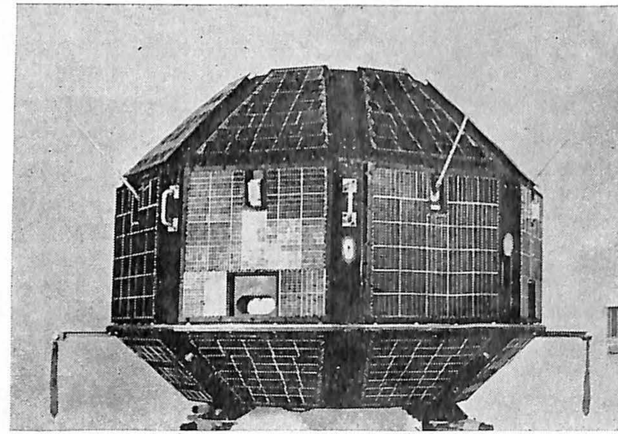
Aerospace materials required for rocketry applications such as special catalysts, ablative and heat-resistant materials and fibre-reinforced plastics for making motor cases have been developed and are produced at VSSC. Special heat-treatment and manufacturing processes have also been evolved to make special alloys for rocket components.

In avionics, the main activities are in the development of space vehicle control and guidance systems and instrumentation for evaluating the performance of various propellants and rocket motors under static and flight conditions. Electronics activities are oriented towards achieving self-sufficiency in ground-based and vehicle-borne systems. Most of the telemetry, telecommand and tracking systems have been developed and successfully tested in flights.

Satellites

—Aryabhata

Named after the famous ancient Indian astronomer and mathematician, Aryabhata, this satellite was designed and fabricated by ISAC. It was successfully launched on April 19, 1975 from the Soviet Union with the help of a Soviet rocket into a near-circular orbit of 600-km altitude at an inclination of 50.7° to the equator. The 360-kg satellite is orbiting the earth once every 96.7 minutes. The ground station at SHAR Centre receives signals from the satellite and sends commands to it. All the technological subsystems on board the satellite



Aryabhata

have been functioning according to design expectations. The spin stabilisation system has excelled design calculation. Owing to low rate of spin decay, achieved as a result of efficient fabrication methods employed, the useful life of the satellite has been extended well beyond its original goal of six months.

Besides the technological sub-systems for monitoring and controlling the functions of the satellite, Aryabhata, has three scientific experiments on board. Due to the failure of one of the 14 regulators in the power system, the scientific experiments had to be switched off on the fifth day after the launch. The data recorded by two of these experiments during the first few days have, however, provided interesting scientific results.

A number of technological experiments have been carried out with Aryabhata. These include tracking experiments using tone-ranging, Doppler and interferometry techniques for determining the position of the satellite in space. They have provided useful information which will be helpful in planning future satellite systems.

◁ Delhi Earth Station

A communication experiment was successfully conducted by transmitting live voice messages from the SHAR ground station to a small ground station at Bangalore via Aryabhata. Similarly electrocardiogram signals and weather data were transmitted in real time via the satellite from SHAR to Bangalore.

Aryabhata is the result of a truly national effort. During its fabrication, ISRO made use of the infrastructure of the nation's industry, both in the public and private sectors. Many small scale industries also made significant contributions to the success of this satellite.

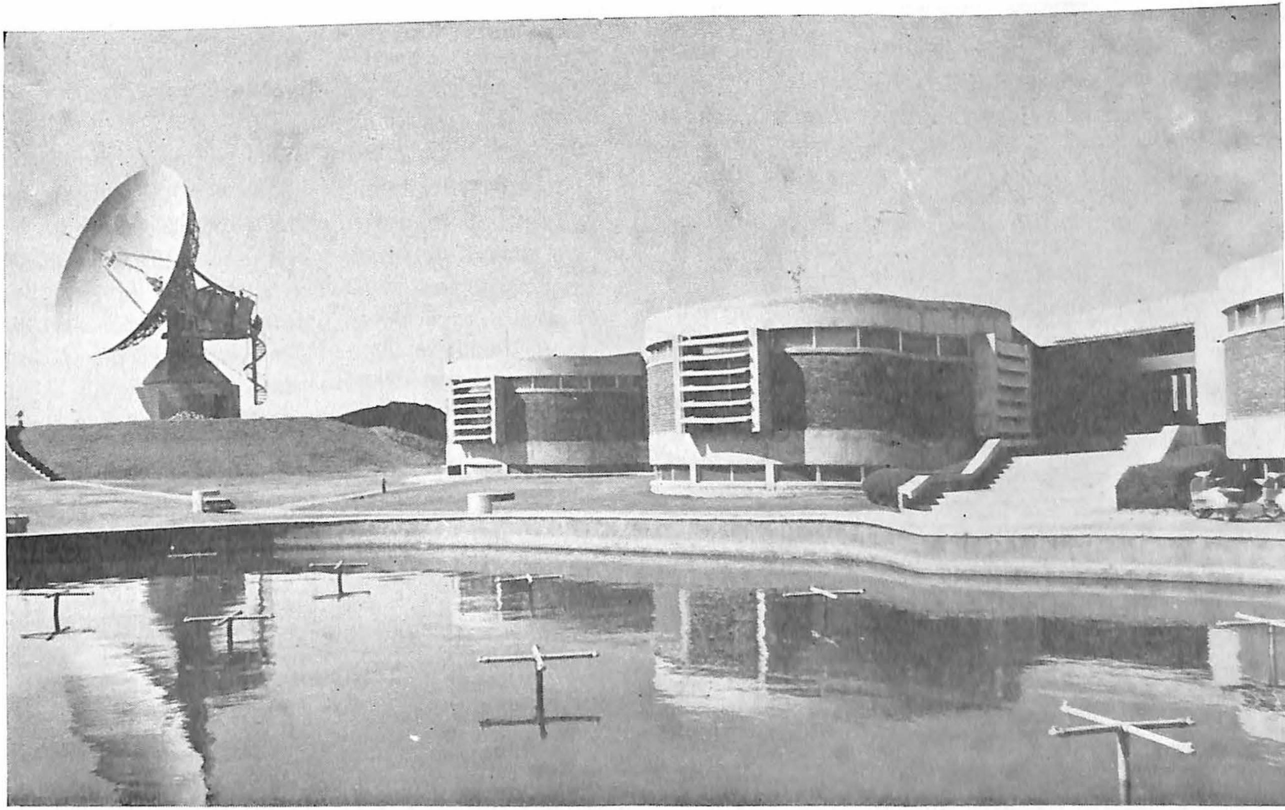
With the launching of Aryabhata, India has acquired indigenous capability in satellite technology, namely, to design and fabricate a spaceworthy system and evaluate its performance in orbit, evolve the methodology of conducting a series of complex operations on the satellite and set up the necessary receiving, transmitting and tracking systems besides the establishment of the infrastructure for fabrication of satellite systems.

Multi-disciplinary

Space techonology is multi-disciplinary and requires the involvement of experts in many fields such as aerodynamics, avionics, chemical technology, computer technology, material sciences and structural engineering. Development of space vehicles—rockets and satellites—is a complex process demanding stringent measures of accuracy, reliability and compactness of design. Various aspects of space flight such as control and guidance of the vehicle into the desired trajectory/orbit, tracking the flight path, maintenance of the vehicle's attitude in space and transfer of information to and from the vehicle in flight, require the use of highly sophisticated techniques and instruments.

—Satellite for Earth Observations (SEO)

ISAC has taken up the development of the second Indian satellite, 'Satellite for Earth Observations' (SEO).



Experimental Satellite Communication Earth Station, Ahmedabad

SEO is designed to conduct experimental studies in earth observations and will carry sensors operating in the visible, near-infrared and microwave frequency bands. The satellite will collect data on hydrology, forestry, oceanography and meteorology. The onboard sensors will consist of two TV camera systems and a microwave radiometer system which are being developed by SAC.

The TV cameras will pick up reflected solar radiation in 0.54 to 0.66 and 0.75 to 0.85 micrometre wavelength regions from the ground during day-time passes of SEO over India. Each picture frame will 'see' an area of 325 km by 325 km with a resolution of one km. The images collected by these TV cameras will be able to provide information relating to general mapping of land into different types like arable land, forests, water bodies and earth's physiography, namely, mountain ranges and river basins with various degrees of vegetation, etc.

The onboard microwave radiometer system will consist of a two-frequency Dicke type radiometer operating at 19.35 GHz and 22.235 GHz. The system will monitor the fluctuation of microwave radiation from sea surface, yielding information on sea state and sea surface temperature. The data will be useful for meteorological purposes.

In addition to these sensors forming the payload, the satellite will have thermal control system, power system, down and up links, attitude sensors and control and stabilisation systems. SEO will also be launched from the Soviet Union in 1978 into a near-circular orbit of 500 km nominal altitude at an inclination of 51° with an estimated orbital period of 95 minutes. The mission control centre will be located at the SHAR Centre and the ground stations at Trivandrum and Ahmedabad will also receive signals from SEO.

—Rohini satellites

The first Rohini Satellite (RS-1) is being designed to monitor the performance of the fourth stage of SLV-3 which will inject the satellite into an earth orbit. It will also monitor the parameters of injection (such as altitude, injection angle and velocity), orbital path after injection and the housekeeping data of the satellite itself while in orbit.

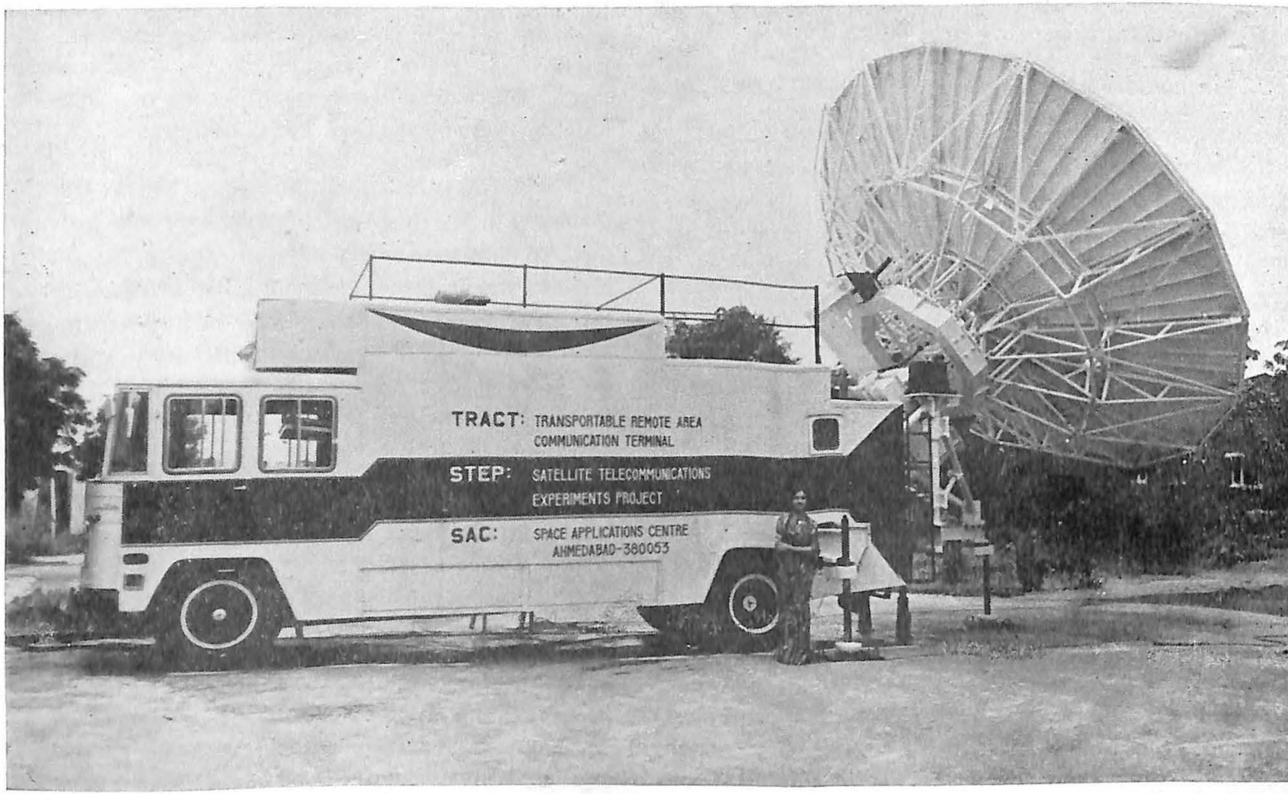
Satellite communications

—*Satellite Instructional Television Experiment (SITE)*

This experiment was conducted between August 1, 1975 and July 31, 1976 as a collaborative programme of India and USA, using the geostationary satellite, ATS-6 (sixth in the series of Applications Technology Satellites) of the US National Aeronautics and Space Administration (NASA) and the ground systems built by ISRO. Under this programme 2,400 villages spread over Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Orissa and Rajasthan regularly received a total of four hours of instructional TV programmes every day. The TV programmes were transmitted to the satellite, ATS-6, from ISRO's earth stations in Ahmedabad and Delhi, and ATS-6 in turn broadcast the programmes. Each village had a Direct Reception System (DRS) comprising a community TV set augmented with a special antenna and frequency converters to pick up directly the TV signals broadcast by ATS-6. The objective of this experiment was to demonstrate the use of direct broadcast of television programmes via satellite for rural development. The instructional elements of the programmes were in the fields of agriculture, health and family planning, education and national integration with emphasis on rural development. Education and information inputs were provided in Hindi, Kannada, Oriya and Telugu.

SITE was an interministerial project of the Government of India. Responsibilities were shared between the Department of Space and the Ministry of Information and Broadcasting through their respective agencies: ISRO and the All India Radio (AIR). The other Government agencies who have contributed to the successful execution of this project are the Ministries of Education, Agriculture, Health and Family Planning as well as the Governments of the states where SITE clusters were situated.

The ground segment hardware was the main responsibility of ISRO which included the setting up, operation and maintenance of the earth stations in Ahmedabad (prime station) and Delhi, the receive-only earth station at Amritsar for local rebroadcast, the mono-pulse beacon station at Nagpur to help ATS-6 keep pointing towards the centre of India, and the development of DRS and their deployment and maintenance in SITE villages. In addition, ISRO had installed



Transportable remote area communication terminal a TV transmitter at Pij in the Kheda District of Gujarat for broadcasting TV programmes to rural areas in and around that place. This transmitter was connected to the TV studio at SAC through cable and microwave link and used to receive programmes from there.

AIR handled production of the TV programmes. The instructional programmes, combining developmental themes with entertainment in a pattern acceptable to villagers, were made at the AIR studios in Delhi, Hyderabad and Cuttack. ISRO, at its studios in Ahmedabad and Bombay, also produced some programmes on science education and Gujarati programmes for transmission from Pij.

The impact of the instructional TV programmes on the SITE villages is being assessed. A large number of social scientists are working on this and many of them are based in those villages for collecting data. A comprehensive social evaluation of SITE is expected to be completed soon. Social scientists from various Indian institutions are cooperating in this task.

SITE was perhaps the most complex mass communication experiment using a satellite ever undertaken anywhere. A direct broadcast satellite system of this magnitude with the necessary infrastructure for maintenance, feed-back and evaluation has never been tried before. Technological, managerial and software challenges of putting this experiment together and operating it have been exceptional. By meeting these challenges successfully and conducting the experiment smoothly, India has gained expertise and confidence to take up still more challenging tasks involving satellite communication.

Other programmes

The Ahmedabad Earth Station (AES) of SAC was set up in 1967 with the assistance of the United Nations Development Programme (UNDP) and its technical consultants, International Telecommunication Union (ITU). AES has a 14-metre diameter steerable antenna. SAC has used this station to conduct training programmes in satellite communication technology for Indian engineers and those from many other developing countries. Between November 1967 and January 1974, nine training courses, each of three months duration, were organised. A total of 80

Indian engineers and 90 engineers from 32 countries in Asia, Africa and East Europe have been trained under this programme. The electronics for this station was modified to enable it function as the prime earth station for SITE.

During the last few years SAC has developed several antennae for other earth stations and the total electronics required for their operation. The electronics sub-systems have been tested to international specifications and many of these are of use in other communication systems such as troposcatter links and radars. In the area of high power feeds and microwave radiometers, SAC has developed considerable expertise and has supplied several feeds to other national agencies.

Transmitters in the millimetre wave band have been developed and used with ATS-6, to determine the propagation characteristics at these wave bands under various climatological conditions. This information will help define the parameters of future satellite communication systems operating in these wave lengths.

New results have been achieved in video technology including development of solid state TV trans-

An infrared false colour imagery obtained through remote sensing technique.

mitters, video switchers and novel modifications in the use of ½" portable video tape recorders. Antennae for VHF TV transmitters have been developed and manufactured with the help of small scale industries. A great deal of expertise has also been gained in the design of low-cost TV studios producing developmental TV programmes.

During 1977-79, ISRO is conducting, jointly with the P & T Department of the Ministry of Communications, a satellite communication experiment using a transponder on board the Franco-West German satellite named 'Symphonie'. This experiment involves remote area communication using transportable terminals, radio networking, emergency communications, digital communications with multiple access, integration of satellite circuits into the terrestrial network and multiple audio and video transmissions. The design and fabrication of the ground equipment for this experiment are the responsibility of ISRO, P & T and the Indian Telephone Industries. Besides, studies are underway to define a satellite system to meet national requirements for telecommunications, television broadcasting and meteorological data collection.

Remote sensing

ISRO activity in this area is aimed at evolving a multi-disciplinary technology for providing useful information on India's renewable and other natural resources. The remote sensing techniques can be applied for a wide range of purposes such as collection of data relating to agriculture—crop vigour, crop census, classification of soil, etc, —detection of minerals, management of water resources, forest inventories, meteorological studies, etc. SAC is developing sensors for use in collecting data for these applications. Some of these sensors are : infrared scanner, multispectral scanner, microwave radiometer and the vidicon TV camera. These will be operated from different platforms, namely, aircraft, balloon or satellite.

About ten remote sensing experiments have so far been conducted and most of them used air-borne multispectral cameras to take photographs for studying aspects of agriculture and landscape features. Such aerial campaigns were conducted over sites in Poona, Bombay, Sriharikota island, Jaipur, Bangalore, Anantapur District in Andhra Pradesh, Patiala District in Punjab and Panchmahals District in Gujarat. A balloon survey was made over Hyderabad area from a height of about 27 km and different features of the ground could be clearly identified in the photographs. A survey of coconut plantation north of Quilon in Kerala was made from a helicopter platform in 1970. This was India's first experiment in remote sensing and it was conducted to detect sick coconut trees so that spread of diseases could be checked. Most of these experiments were meant for gaining expertise in remote sensing technology and to establish the utility of its application for various purposes.

The aerial surveys over Ananthapur and Patiala districts were carried out during late 1974 and early 1975, jointly with the Indian Council of Agricultural Research (ICAR) under the Project, Agricultural Resources Inventory and Survey Experiment (ARISE). Classification and identification of various kinds of crops and other agricultural resources were found to be feasible using the remote sensing techniques. Crop acreages and land-use classifications were also made. The results of ARISE clearly indicate that the level of detail which remote sensing data can provide is far higher than the data collected by conventional means. This has important implications in planning at the micro level. A major finding of ARISE is that the acreage under rice cultivation in Ananthapur District was significantly under-estimated in the data available earlier. Also, many so-called 'reserve forests' showed depleted vegetation.

The aerial survey of Panchmahals District was conducted in early 1976, in collaboration with the Gujarat State Government, for the collection of data on land-use, forests and geological features which will be useful in the development of that area.

Aerial observations were conducted over the Arabian Sea near Bombay and Cochin during May-June 1975 using a thermal infrared scanner to record sea surface temperature variations. Preliminary results of the survey indicate warming up of the sea about 150 km off the coast before the onset of monsoon.

Monsoon studies

India will participate in the Monsoon Experiment (MONEX) which is a sub-programme of the Global

Atmospheric Research Project (GARP) that envisages synoptic global meteorological observation for realistic medium and long range forecasting. GARP has been formulated as an international research programme jointly by the World Meteorological Organisation (WMO) and the International Council of Scientific Unions (ICSU). MONEX will be conducted during 1979 in two phases for the study of the summer monsoon (south-west) and the winter monsoon (north-east). The meteorological data from the land and sea surface along with those collected at different altitudes are needed for understanding the complex nature of the monsoon. Orbiting and geostationary satellites launched by other countries, instrumented balloons, aircraft, ships and fixed and floating buoys at sea, along with land-based observation stations and meteorological rocket launchings, would be used for collecting the data. The India Meteorological Department will be the main executing agency of this project. ISRO's contribution will constitute collection of data using rockets and air-borne thermal infrared scanner, reception of data from satellite, etc. As a prelude to MONEX, a series of field experiments known as Monsoon-77 is planned over the Arabian Sea and the Bay of Bengal during the summer of 1977 with the participation of the Soviet Union.

Sponsored research

In addition to the space research activities carried out at its Centres, ISRO encourages and supports scientists at various universities and research institutions in the country for conducting research and development studies in space sciences, space technology and space applications relevant to the Indian space programme. A large number of research proposals have been received from scientists of various institutions for such support. By now, about 30 of them have been funded. Such research projects cover upper atmospheric physics, astronomy, cosmic-rays, development of remote sensing scanners, application of remote sensing techniques for natural resources study, development of high energy propellants, development of antenna for millimetre wave propagation, satellite dynamics, spacecraft technology, etc. Besides, ISRO partly funds scientific publications brought out by various Indian institutions.

TERLS
Control
Centre

INTERNATIONAL COOPERATION

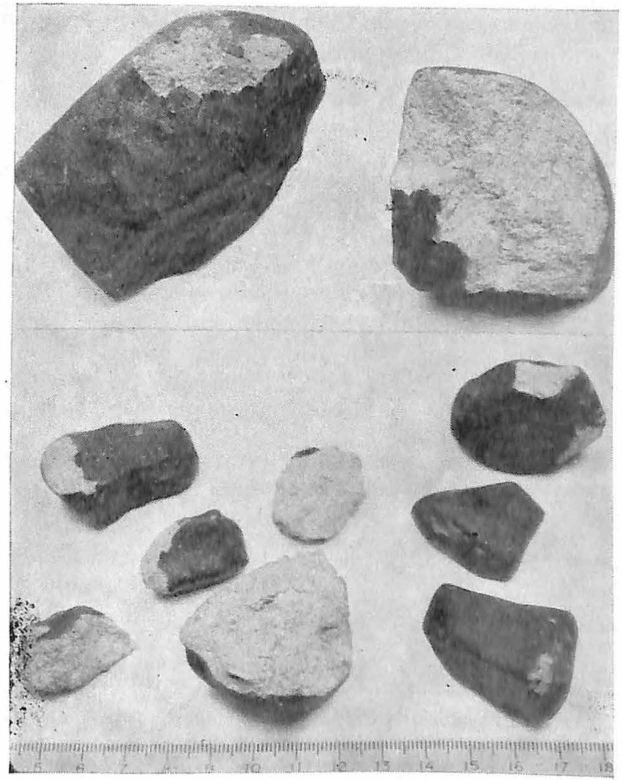
Collaboration with the space agencies of other countries forms an important part of the Indian space programme. Such collaboration can be broadly categorised as follows :

Facilities

In setting up TERLS, support in the form of equipment was provided by NASA, the Centre National d'Etudes Spatiales (CNES) of France and the Hydro-Meteorological Services (HMS) of the Soviet Union. Scientists from countries such as USA, USSR, UK, France, Japan and West Germany have conducted scientific investigations at TERLS using rockets.

The United Nations Development Programme (UNDP) and its technical consultants, the International Telecommunications Union (ITU), have provided support in establishing AES and in augmenting its facilities so that it could be used as the prime earth station for SITE. ISRO has conducted training courses in satellite communication technology, using

Some of the meteorites under study at PRL ▷



the facilities at AES, for trainees from many developing countries along with those from India.

The USSR Academy of Sciences has provided equipment for the setting up of a satellite tracking station at Kavalur in Tamil Nadu.

Satellite programme

The satellite ATS-6 of NASA was used for SITE, and the USSR Academy of Sciences has launched Aryabhata. The Academy has agreed to launch SEO also. The Satellite Telecommunications Experiments Project (STEP) which began in June 1977, utilises the Franco-West German satellite Symphonie.

A proposal made to the European Space Agency (ESA) for utilising the qualification flights of their Ariane Launch Vehicle for orbiting ISRO's experimental geostationary communications satellite has been accepted.

Space sciences

Since December 1970, the Soviet M-100 rockets are regularly being launched from TERLS for collecting meteorological data. More than 300 such rockets have been launched so far.

In support of research programmes in different areas of space sciences at various academic institutions in India, NASA, on the recommendation of ISRO, has provided important scientific instruments and lunar samples.

ISRO is sponsoring a collaborative gamma-ray astronomy experiment using balloons from the balloon launching facility in Hyderabad. Indian and Soviet scientists will participate in this experiment, for which launchings will be made during October-December 1977 and March-April 1978.

An Indian experiment for studies on the ionisation states of solar and galactic cosmic ray heavy nuclei will be flown on board Spacelab-I, a joint mission of NASA and ESA.

Others

ISRO is fabricating and supplying high-accuracy pressure transducers for use in the development of the European satellite launch vehicle, Ariane.

ISRO scientists and engineers have been offered training facilities in space sciences and technology by French and West German space agencies.

Many schemes for cooperation with developing countries in various aspects of the space programme are being planned. □

SPACE TERMS

ARTIFICIAL EARTH SATELLITE

This term applies to any man-made object placed in a near-periodic earth orbit in which it moves mainly under the gravitational force of the earth. Satellites are used for various purposes such as scientific investigations, meteorological studies, telecommunications and remote sensing. Satellites are launched with the help of large rockets, usually called launch vehicles, which carry and inject satellites into pre-determined orbits.

EARTH STATION

It is a ground system equipped to be in radio contact with space-borne satellites. A typical earth station has a large parabolic antenna for transmitting and receiving signals. However, depending on the system needs, earth stations with receive-only capability are also set up. ISRO's prime earth station for the operation of SITE was located at the Space Applications Centre, Ahmedabad. Other earth stations at Madras and Delhi will also form part of India's experimental network.

DIRECT RECEPTION SYSTEM

This system finds application in broadcasting satellite services, whereby modulated TV signals are received directly from the satellite by small earth stations. The Direct Reception System (DRS) comprises a small and inexpensive parabolic antenna, an instrument called the Front-End Converter (FEC) and a ruggedised TV set. The antenna receives TV signals transmitted by the satellite. The FEC modifies and amplifies the TV signals and feeds them to the TV set. The use of the satellite and DRS eliminates the need for an expensive network of ground-based TV relay stations. Two thousand four hundred DRS units were deployed by ISRO in as many villages for receiving television signals directly from the satellite during SITE programme. DRS is designed to operate with a battery, if necessary, and can, therefore, be installed in remote parts of the country where electricity is not yet available.

GEOSTATIONARY SATELLITE

The time taken by a satellite to complete one revolution around the earth is determined by the altitude at which it is orbiting. For instance, Aryabhata orbiting at an altitude of about 600 km takes about 96.7 minutes to go around the earth once. The higher the altitude of the satellite, the longer it takes to complete one revolution. If a satellite is put into an equatorial orbit at about 36,000 km above the earth's surface, the period of the satellite's revolution around the earth coincides with the period of the earth's rotation about its own axis. This orbit is called 'Geosynchronous' or 'Geostationary' since the satellite's journey around the earth is synchronised with the speed of the earth's rotation and, therefore, the satellite appears stationary relative to any point on the earth. Such geostationary satellites are used for communication purposes since the antenna of an earth station, once adjusted pointing towards the satellite, can be kept continuously in contact with the latter for a long time. The NASA satellite, ATS-6, used for the SITE programme, was such a satellite.

IONOSPHERE

The atoms and molecules of gases present in the upper atmosphere get electrically charged due to collision with particles like photons (light), electrons, protons, etc, coming from the sun and other cosmic sources. This charged, or ionised, state occurs in the upper atmosphere above an altitude of 60 km. This region, called ionosphere, acts as a sort of mirror in reflecting radio waves for long-distance radio communication. Understanding different aspects of the ionosphere is of great importance in radio communication.

MAGNETIC EQUATOR

This is an imaginary line on the surface of the earth connecting all points at which a magnetic needle, when freely suspended, is perfectly horizontal. At magnetic poles (which are slightly shifted from the geographic poles), such a needle will be perpendicular to the horizon. This line lies fairly close to the geographical equator, but passes to the north in Africa and the Indian Ocean, and to the south in America and the eastern Pacific.

Thumba has gained importance because of its proximity to the magnetic equator. An intense narrow sheet of electric current, called Equatorial Electrojet, which flows from west to east at a height of about 100 km above the ground is responsible for many interesting ionospheric phenomena originating in this region.

MICROWAVES

Microwaves are electro-magnetic radiations, with wavelengths longer than that of light. These are used for high-efficiency radio communication and for remote sensing for resources survey and meteorological data collection. The characteristic length of microwaves varies between 1 mm and 50 cm. Because of its high frequency, it is least affected by ionospheric disturbances and so used for satellite communication. Ground-based communications systems also use microwaves.

PAYLOAD

In the context of space research, it means the equipment designed to collect data in space, and carried aboard a rocket, a satellite or any other space-craft. A payload does not form part of the basic mechanism of a rocket or the satellite. For instance, a satellite housed atop a rocket is called a payload of the rocket, while the satellite itself may have payload that will conduct scientific observations once it is in orbit.

PROPELLANT

It consists of a chemical fuel and an oxidiser, and is used to propel a rocket. The combustion of the propellant generates an enormous amount of gas at high pressure. This gas is ejected through the nozzle of the rocket at very high speeds and, as a reaction the rocket is propelled in the opposite direction. Since one of the constituents of the propellant is an oxidiser, it can burn even in vacuum where conventional fuel cannot burn. Propellants could be in solid or liquid states. In solid propellants, the fuel and the oxidiser are ready-mixed. In liquid propellants, on the other hand, the fuel and the oxidiser are in liquid form and are stored separately within the rocket. They are brought together into the combustion chamber for burning which can be controlled through valves in the ducts.

REMOTE SENSING

Remote sensing is the process of detecting the nature or properties of an object without actually being in contact with it. In the present context it concerns the survey of natural and renewable earth resources from air-borne and space-borne platforms. The remote sensing technique is based on the fact that every object has its characteristic radiations and also it reflects various incident radiations in a way which is different for different objects. These radiations and reflectances can be detected by various types of sensors that are carried aboard aircraft, balloons or satellites. Different types of vegetation, soils, water and mineral deposits have their individual patterns of radiation and a sensor can accurately distinguish one from the other. Visual photo-interpretation and computer data processing methods are employed to accurately map various resources and land-use pattern, using the imageries produced by the sensors.

SOUNDING ROCKET

This is a rocket equipped with instruments to conduct meteorological or scientific observations in the upper atmosphere. The rocket, launched near vertically, penetrates the atmosphere. The meteorological/scientific payload housed in its nosecone, during its ascent and descent through the upper atmosphere, collects data and transmits to the ground. Sounding rockets thus aid the study of various properties of the upper atmosphere. Menaka, Rohini and Indian Centaure are the sounding rockets developed, built and launched by ISRO.

TELEMETRY

The onboard communication system in a space-borne rocket/satellite sends data which are received by the ground telemetry station. One set of data called 'housekeeping' data sends information about the working of different subsystems of the rocket/satellite. The other set, 'mission' data, relates to the specific task the rocket/satellite is assigned to perform. These data are carried by means of electromagnetic waves in a coded form. The telemetry station on ground has an antenna and supporting equipment such as receiver, computer, quicklook displays, tape recorder for storing data, etc. The antenna tracks the space-borne rocket/satellite and receives data signals. For instance, when Aryabhata passes over the SHAR Centre, the telemetry antenna there establishes radio contact with the satellite, follows its path and receives data until it disappears below the horizon.

TELECOMMAND

Telecommand is the means by which a space-borne craft is controlled from the ground. Commands are sent, by means of electromagnetic waves, from the ground station to the rocket/satellite to make the latter perform specific jobs such as swtiching on or off certain onboard instruments, to activate tape recorders, etc.

TRACKING

This is the process by which the position and velocity, at any instant, of a rocket/satellite in flight are determined. These parameters give information about the trajectory of the rocket and the orbit of the satellite. Tracking can be done by optical and radio techniques. The satellite tracking station at SHAR Centre has radio devices like tone ranging, doppler and interferometer systems and optical devices like kine theodolites.