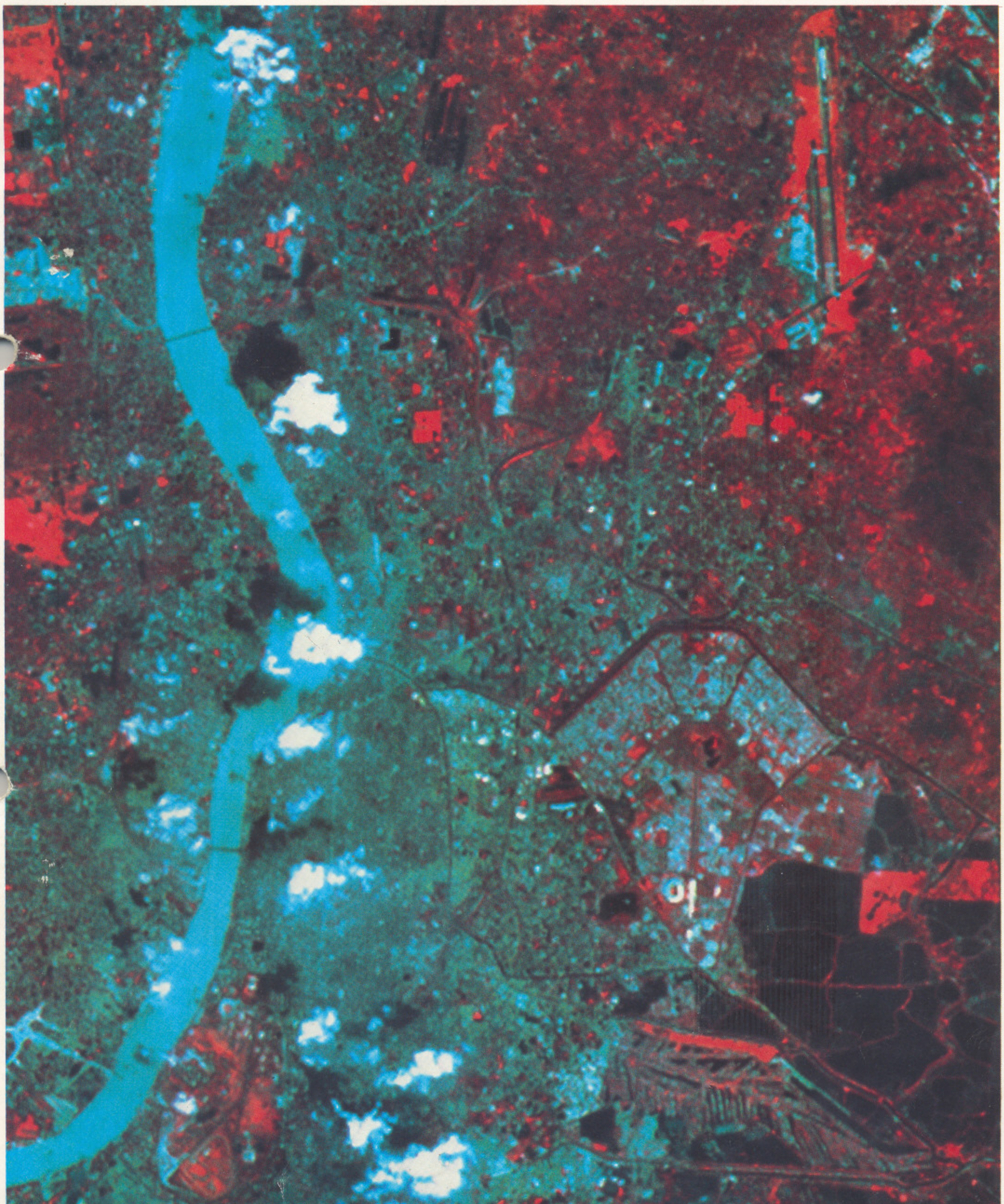
1/1989

SPACE india



INDIAN SPACE RESEARCH ORGANISATION

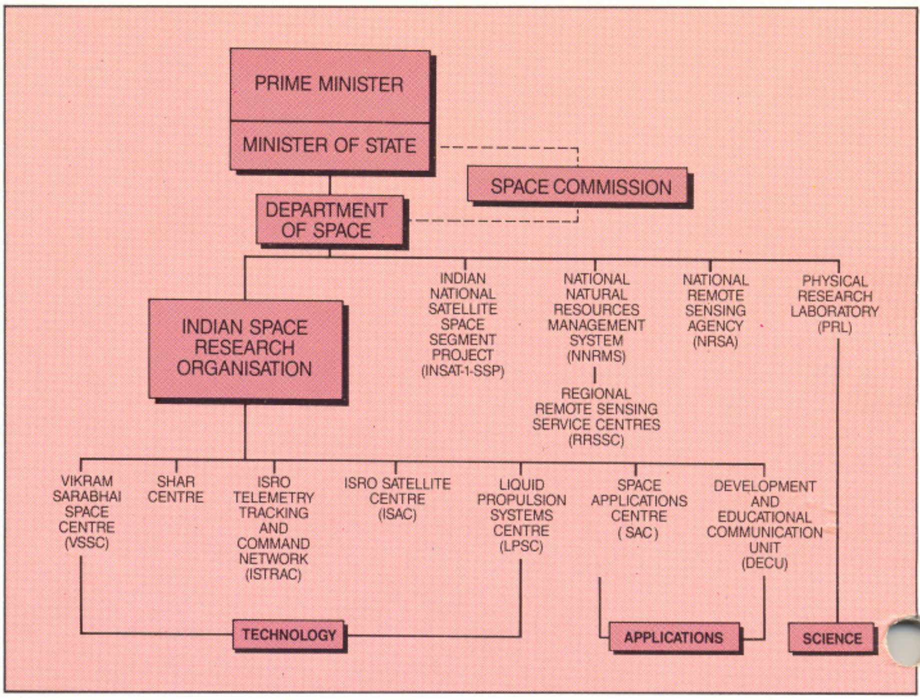
The Indian Space Programme

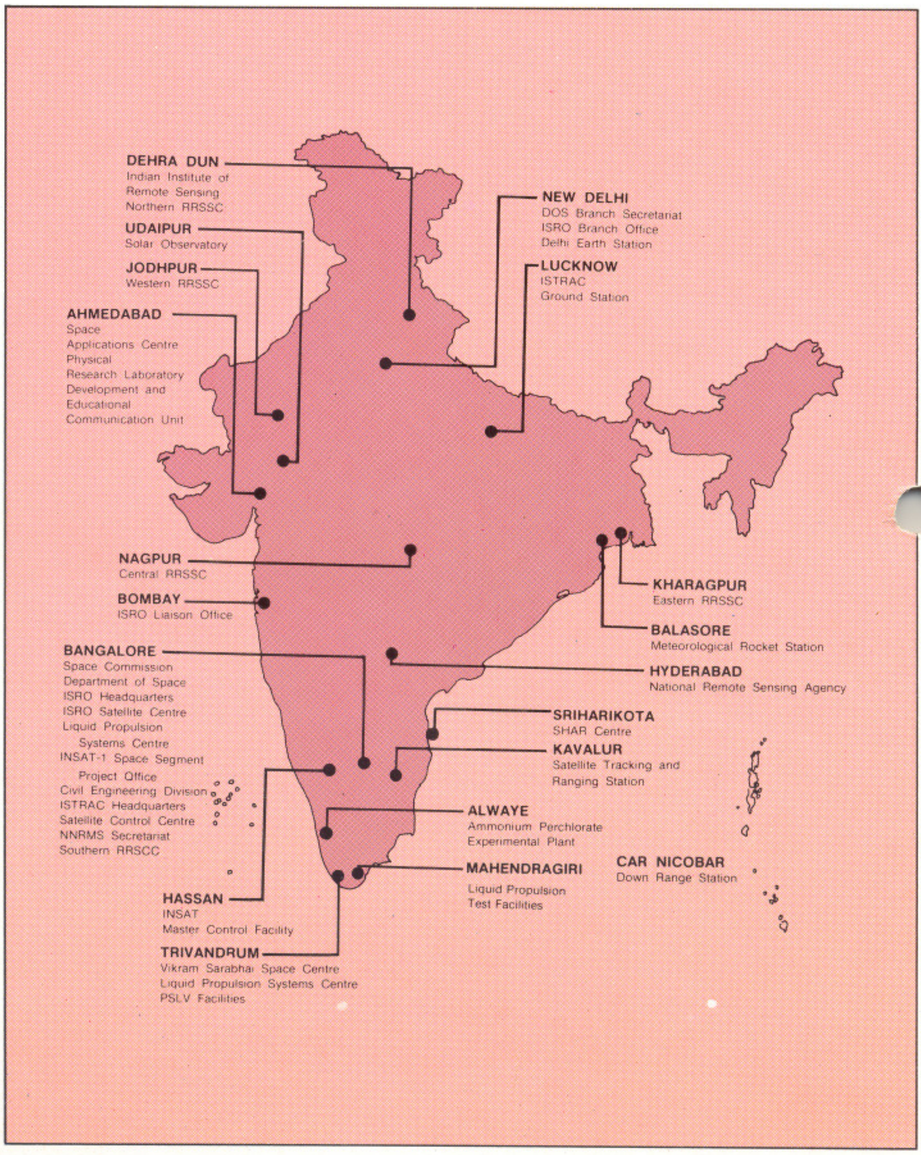
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science and technology for identified national objectives.

The Indian Space Programme is directed towards the goal of self-reliant use of Space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological services and (c) development and operationalisation of indigenous satellites and launch vehicles for providing these space services.

The Indian Space Research Organisation (ISRO) is the research and development wing of DOS and is responsible for the execution of the national space programme. ISRO also provides support to universities and other academic institutions in the country for research and development projects relevant to the country's space programme.

Both the DOS and ISRO Headquarters are located at Bangalore. The development activities are carried out at the Centres and Units spread over the country. □





FRONT COVER
Calcutta city as viewed by IRS-1A

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IRS-1A

One Year in Orbit

On March 17, 1989 the first operational Indian remote sensing satellite IRS-1A completed one year of in-orbit operations. The satellite entered the second year of operations with all on-board systems functioning normally.

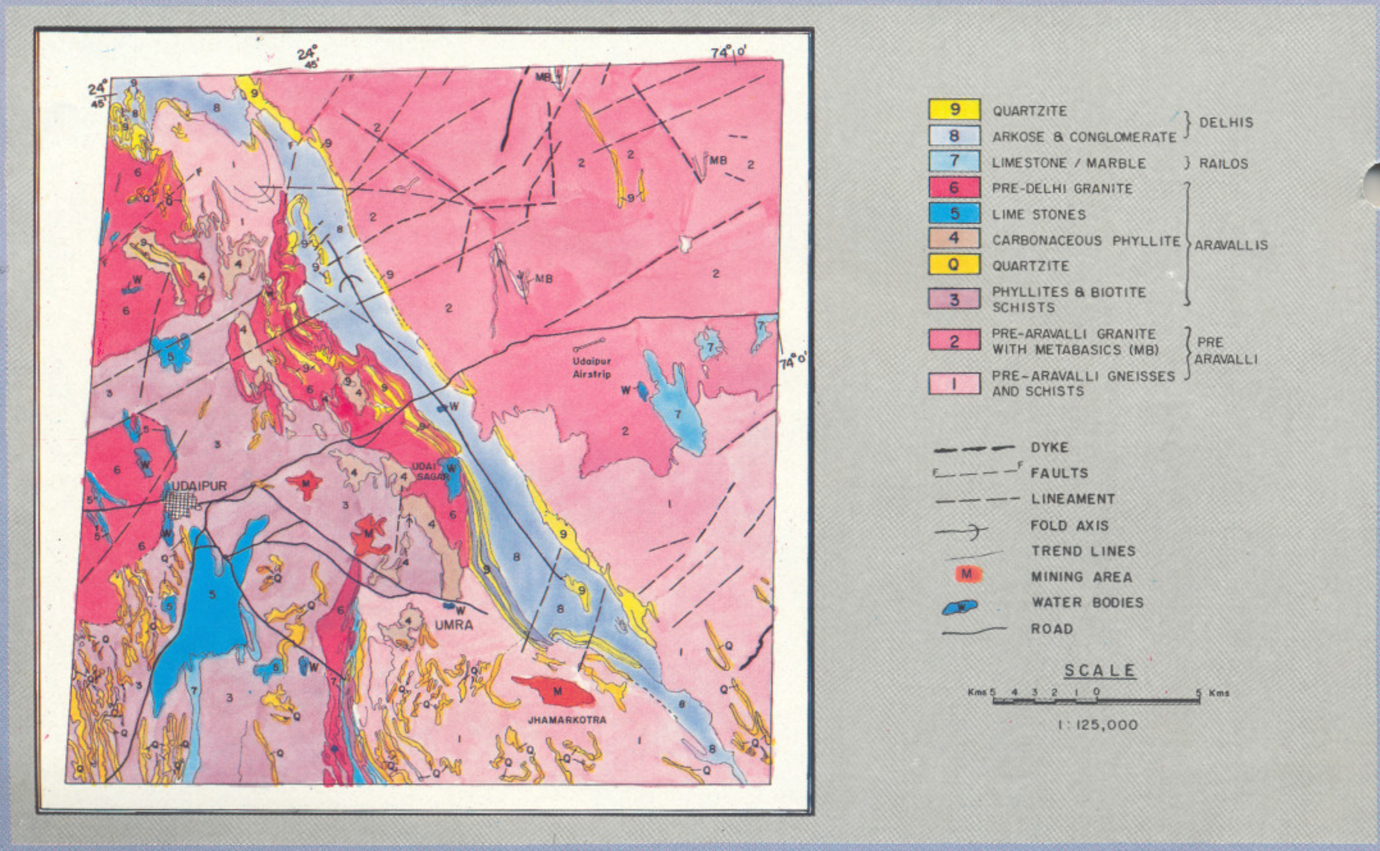
Circling the globe at an altitude of 904 km, in a polar sun-synchronous orbit, the satellite crosses the equator always at 10.25 hrs local time. Whenever it passes over India, the satellite images about 148 km wide strip of the country in the so-called push-broom mode. Because of the continuous rotation of the earth, the distance between strips imaged during two successive orbits is about 2,872 km. As the orbital period of IRS-1A is about 103 minutes, the satellite completes 14 orbits in a day. The satellite's path over India will be shifted by 1.17 degrees of longitude to the west every day. Thus it takes about 22 days for the satellite to cover the entire Indian sub-continent. During the first year of operations IRS-1A repetitively imaged the country 16 times making it possible to acquire more than hundred thousand imageries from the three camera systems on-board.

IRS-1A is designed and built indigenously using a host of state-of-the-art technologies. Noteworthy among these are the reaction wheels and gyroscopes for controlling the orientation of the satellite, hydrazine based reaction control system for precise

Digitally enhanced IRS-1A LISS II image of Doon Valley, Dehra Dun District.

False Colour Composite imagery of Bijapur and Belgaum area from LISS-II Camera of IRS-1A

False Colour Composite of IRS LISS-II imagery of Udaipur — Umra mineralised area, Rajasthan and the interpreted geological map.

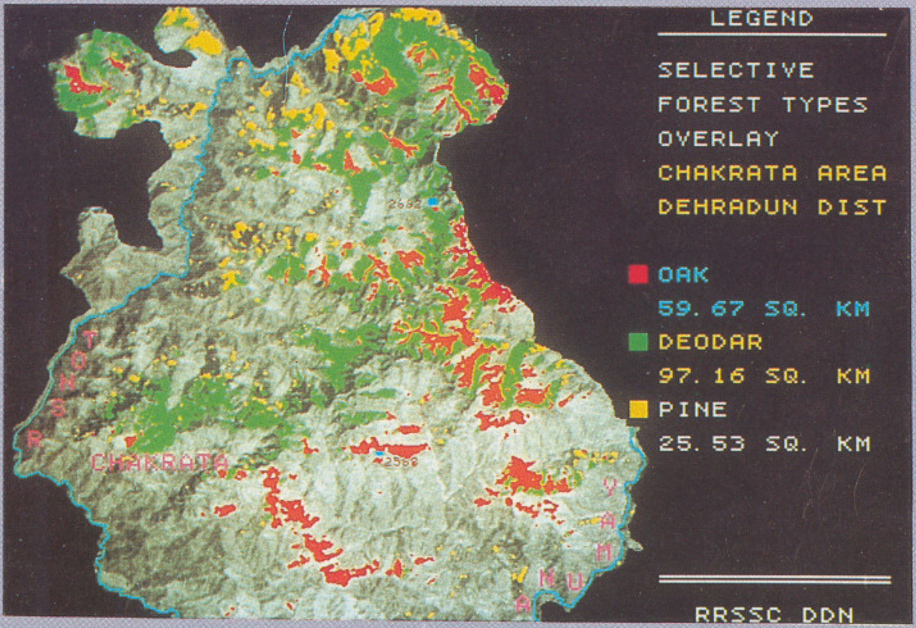


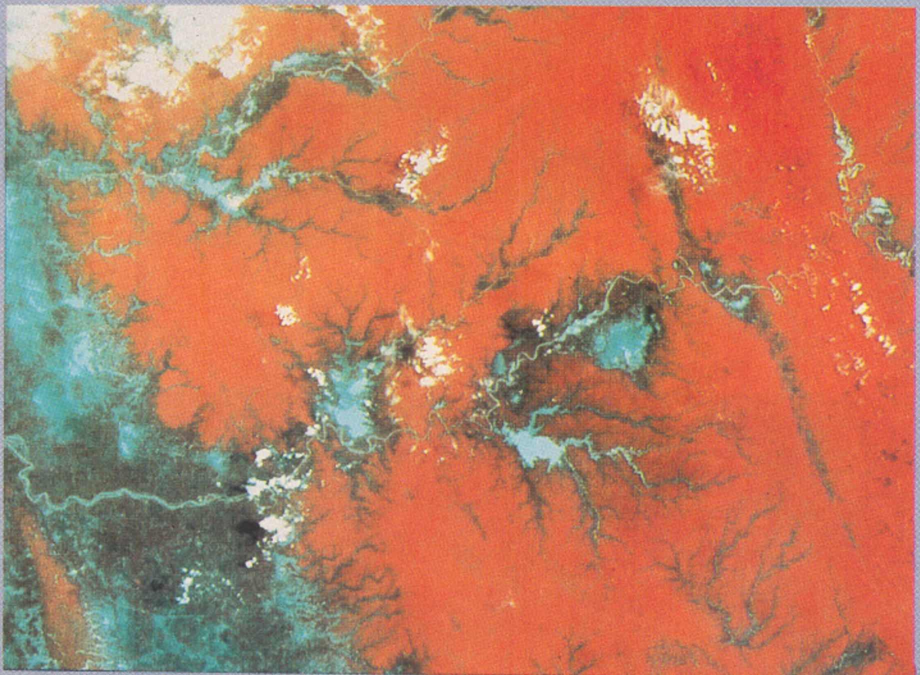
orbital and orientation control, earth and star sensors, large area solar panels for power generation, data communication systems operating in X and S-band frequencies and the imaging camera systems.

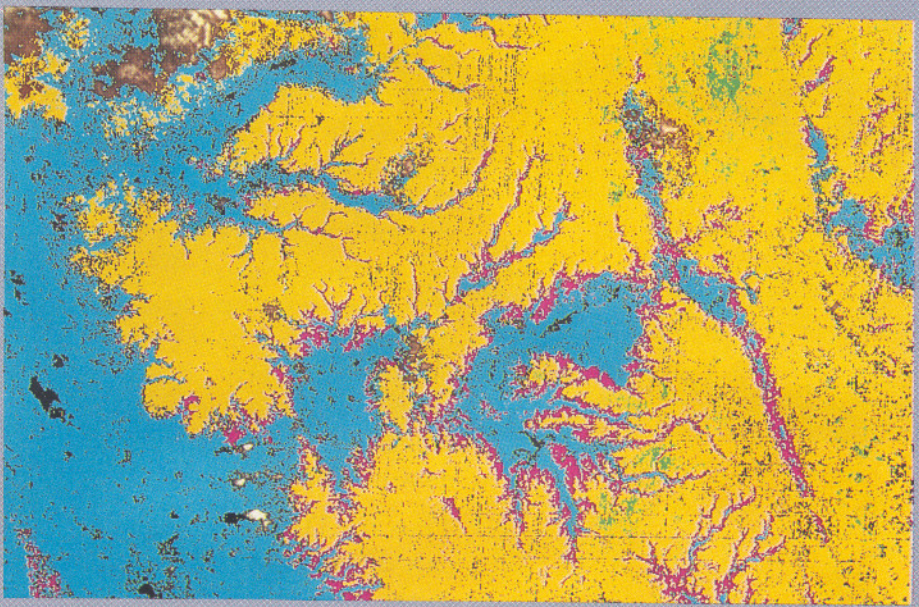
Imageries obtained from IRS-1A are used in applications such as mapping of forestry and waste land, crop inventory, ground water targetting, integrated drought management, regional geological mapping, land-use patterns and a gamut of other resources survey and management areas. The recent floods of the Brahmaputra river were monitored and mapped using IRS imageries for assessing the damage caused.

For agricultural planning, land use mapping of the entire country at district level has been undertaken towards delineation of the agroclimatic zones. Thus the successful operationalisation of IRS-1A and the systems for the reception, processing and dissemination of its data has provided a fully indigenous space segment for the National Natural Resources Management System (NNRMS).

IRS-1A also represents the first of a series of remote sensing missions which would provide services on an assured and continued basis to several user agencies in the country. Based on the estimated nominal life time of 2½ to 3 years for IRS-1A, the launch of IRS-1B, the second in the series is planned for 1991. IRS-1B will be identical to IRS-1A. Continuity of services beyond IRS-1B will be maintained by the second generation IRS series. While the second generation series will be built around the established design and the technology accrued from IRS-1A, they are expected to provide better spatial resolution, more frequent revisit capabilities, stereo viewing and so on. □







Top: A digitally processed IRS-1A imagery showing forest types

Middle and Bottom:

Histogram stretched raw data of IRS LISS-I and colour coded soil erosion map of the same area.

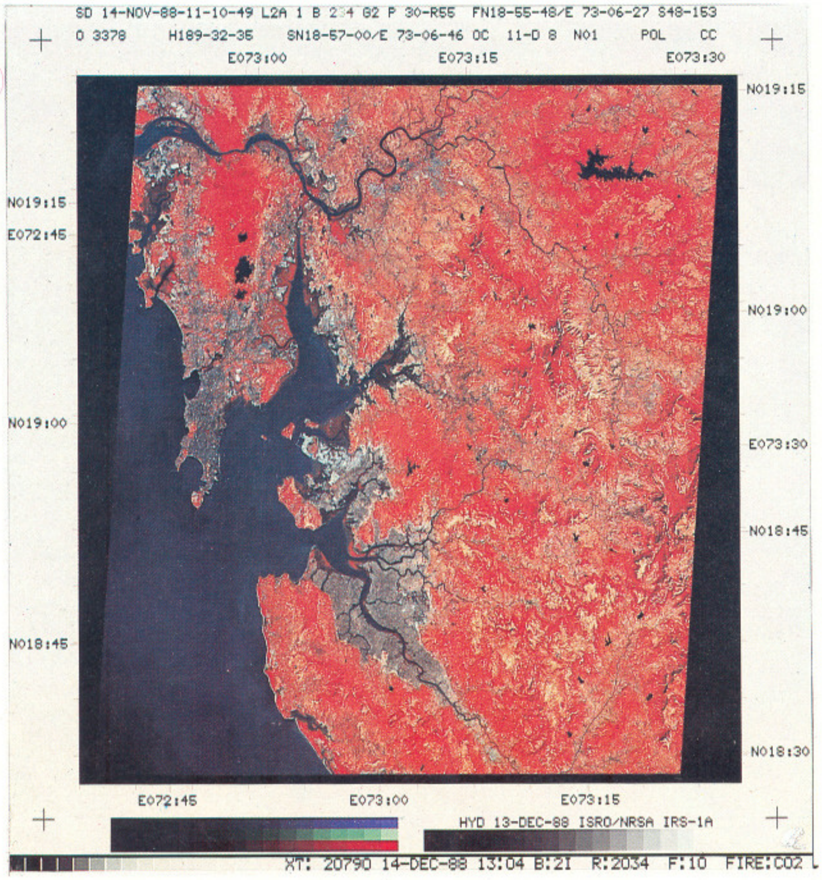
Cyan: Valleys, nil to slightly eroded

Green: Areas with three storeyed vegetation, nil to slightly eroded

Yellow: Areas with moderate slopes and sparse vegetation cover, moderately eroded

Pink: Areas with steep slopes and sparse vegetation cover, severely eroded

Red: Jhoomland



Standard data product of an IRS-1A LISS-II scene showing Bombay and its environs

False Colour Composite of a special product of Bom[...] generated after histogram modification using gaussi[...]

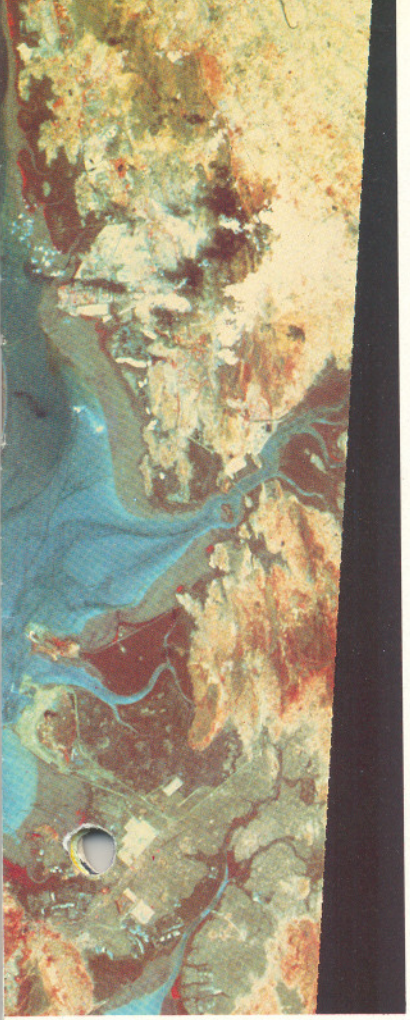
From Bits and Bytes to Images

The IRS Data Product System (DPS) is a vital link between the spacecraft systems and the world of users. The data from the on-board sensors are received and recorded on tapes at the earth station in the form of digital signals. While bulk of this data is information from the imaging sensors it also contains supporting data relating to the spacecraft orbit and attitude information and other housekeeping facilities. While all the signals are in a carefully formatted form, they are not in a fashion that would make any sense to the user. The user needs images in a photographic form. It is the job of DPS to convert the raw satellite data into user friendly data products.

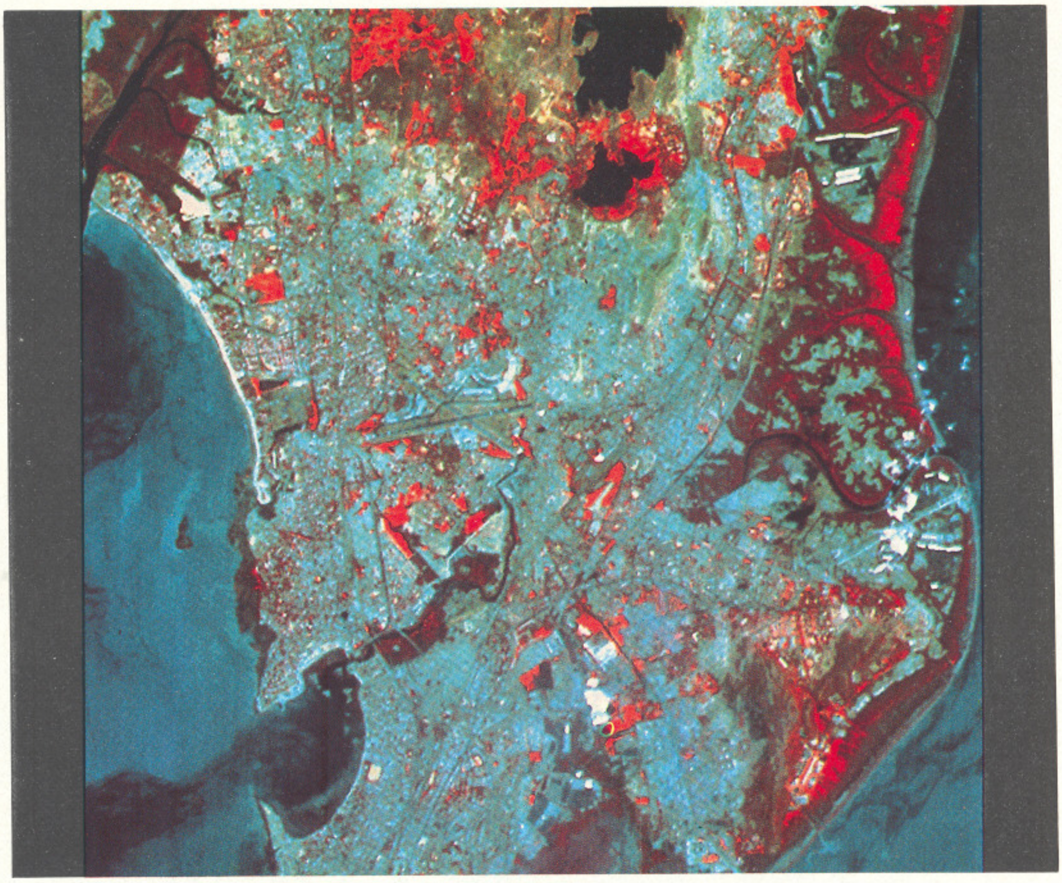
Thus the DPS is an integral part of the total IRS system. It works in consonance with the Spacecraft Control Centre, Mission operations, Data Acquisition System and Telemetry, Tracking and Command Network. The design, development and implementation of the DPS started at the National Remote Sensing Agency (NRSA) much before the launch of IRS-1A. Closely co-ordinated efforts by specialists at the ISRO Satellite Centre, ISRO Telemetry Tracking and Command Network, the Space Applications Centre and NRSA were required to realise the DPS.

The enormity of the data handling requirement is quite evident if you consider the following.

Each day, on an average, about 20 cloud-free scenes are obtained from the LISS-I camera of IRS-1A. These are collected in 4 spectral bands.



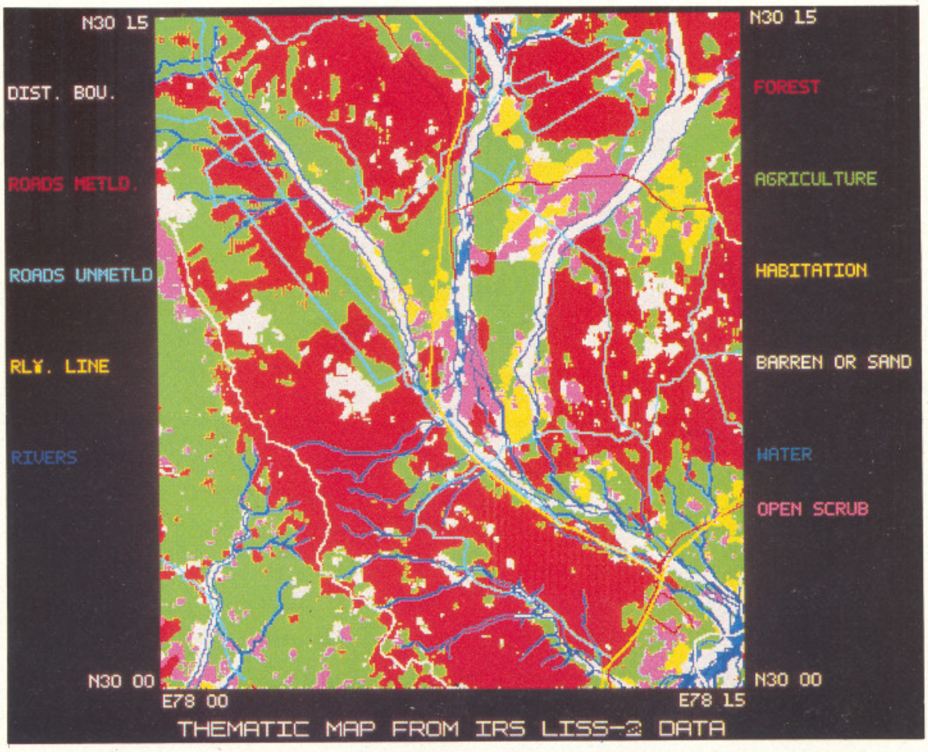
and environs
stretching function.



A portion of the Bombay imagery generated after reducing the noise and stretching the data for enhancement of contrast.

About 4 million picture elements contribute to each of these bands. There are also four scenes collected from LISS-II cameras corresponding to each of the LISS-I scenes.

Hence computerisation and large scale automation is resorted to in the DPS. Another important challenge in the development of the DPS was ensuring processing of data at specified throughput and short turn-around times. It was also essential to adhere to the specified accuracies and use reliable, efficient, portable and maintainable software. The goals were, of course, met on time and the data products started flowing right from the day one. Today more than 300 users are serviced by the NRSA Data Centre. □



Thematic map generated from IRS-1A precision geocoded LISS-II data with linear cartographic features overlayed from Survey of India topo sheet

A National Seminar on IRS-1A mission and its applications potential

Experts panel at the National seminar

Over the past 3 to 4 years there has been an increased use of remotely sensed data for resource inventory and management in the country. Many user agencies utilise satellite imageries for a variety of applications. To assess the applications potential of the indigenous remote sensing satellite and to accelerate the use of IRS imageries, a national seminar on the "IRS-1A mission and its applications potential" was held during December 21-22, 1988 at the National Remote Sensing Agency (NRSA), Hyderabad. The seminar was inaugurated by Prof. M.G.K.Menon, Member, Planning Commission, Govt. of India and Chairman of the Planning Committee of the National Natural Resources Management System (NNRMS).

The national seminar brought together over 150 representatives of user agencies and an equal number of those responsible for the realisation of the IRS-1A systems and the mission. Certain aspects relating to the system capabilities, mission performance characteristics and the data quality were discussed at the seminar. In addition, forty papers were presented by the user community demonstrating the potential of IRS-1A data in the application areas such as agriculture, floods, geoscience, coastal oceanography, land use etc.

A noteworthy feature of the seminar was an exhibition of data products from IRS-1A and selected thematic applications. Several indigenous industries also exhibited their low-cost remote sensing application equipment at the venue.

The concluding session of the seminar was addressed by a panel of experts consisting of the Chairman of the Space Commission, the Secretary of the Department of Mines, the Director General of the Geological Survey of India, the Director of Forest Survey of India, the Director of ISRO Satellite Centre and the Director of the National Remote Sensing Agency. A set of action items and recommendations was drawn up which, it is hoped, would be implemented by all concerned leading to the fulfilment of the goals of the National Natural Resources Management System. □

Recommendations of the Seminar

The Exhibition of IRS-1A products and low cost indigenous remote sensing equipment was a highlight of the seminar.

In order to sustain and further exploit maximally the benefits that would accrue from the availability of space based remote sensing data on a continued and assured basis from the first generation IRS series of satellites and their follow-on second generation satellites with improved and enhanced capabilities, it is of paramount importance that the following actions are initiated and pursued vigorously.

(a) Extend to national level, the applications areas which have already been demonstrated on a pilot scale (eg. agriculture, land use, ground water targetting, vegetation cover, mineral targetting etc.).

(b) Explore new and emerging application areas and initiate focussed efforts (eg. marine resources, oceanography, cartography etc.).

(c) Concerted efforts to equip the user community in the use of demonstrated applications of remote sensing through carefully planned education and training programmes at the grass root level.

(d) Strengthen the mechanism, for interaction and information exchange among the user departments and the agencies at all Central and State Governments level essential for effective use of data and techniques developed for resource management.

(e) Include adequate financial allocations and provide infrastructural support in the Central Government department/agencies and State Governments.

(f) Extend the scope and use of remotely sensed data in even non-governmental sector, by developing entrepreneurs who could commercially exploit the benefits of remote sensing by maximal utilisation of indigenously developed hardware and software capabilities and methodologies through the Indian industry.

(g) Initiate actions for making use of powerful interpretation and data analysis systems which are now available indigenously at competitive and affordable prices for the end users.

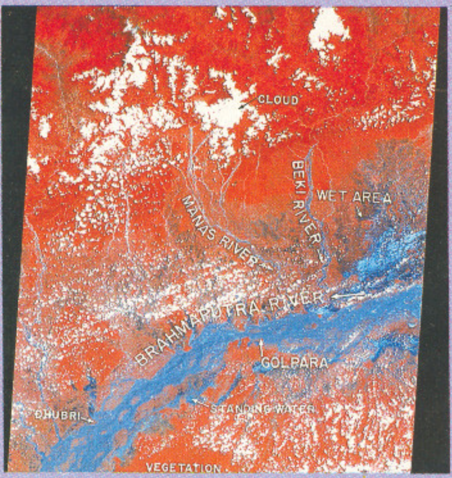
(h) Increase use of digital analysis techniques in view of digital image analysis systems for handling large quantum of data and considering the indigenous availability.

(i) Develop advanced resource management tools and techniques such as Geographic information System (GIS) and Digital Cartographic Data Base (DCDB) to enable the establishment of Natural Resources Information System (NRIS) essential to further accomplish the goals set in these areas of NNRMS.

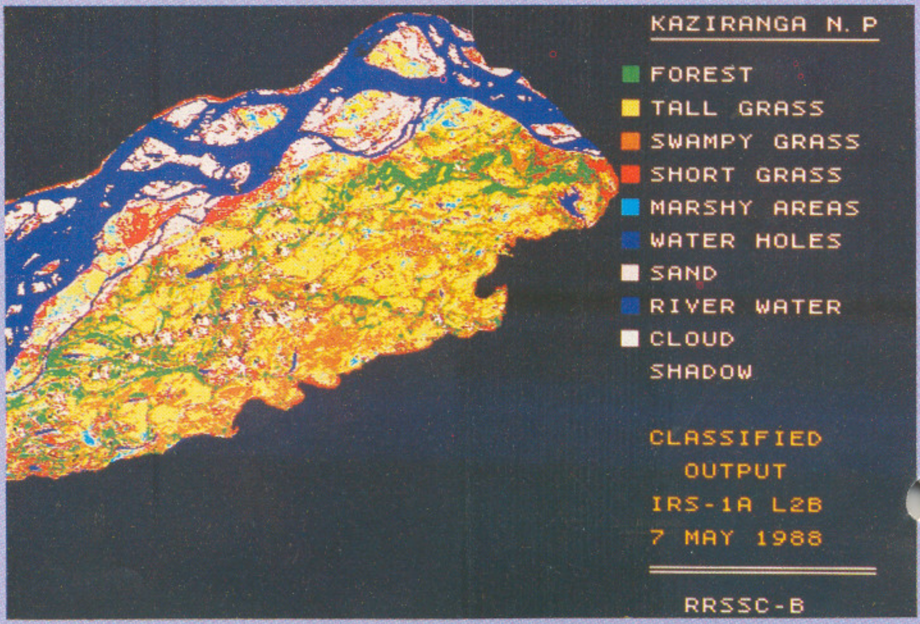
(j) Develop new sensors such as middle infrared and microwave sensors, their associated ground equipment and software for exploring new avenues of applications, while complementing the existing and planned sensor systems in the visible and near infrared bands.

(k) Generate plans for dissemination of relevant data with appropriate time and content for effective end user levels like district level planners.

(l) Initiate actions for establishment of State level Natural Resources Management System to enable effective use of remote sensing technique for resource management at the ultimate level of the end user departments in the States and Union Territories'



IRS Imagery of 31 May, 1988 showing flood situation in part of Brahmaputra valley



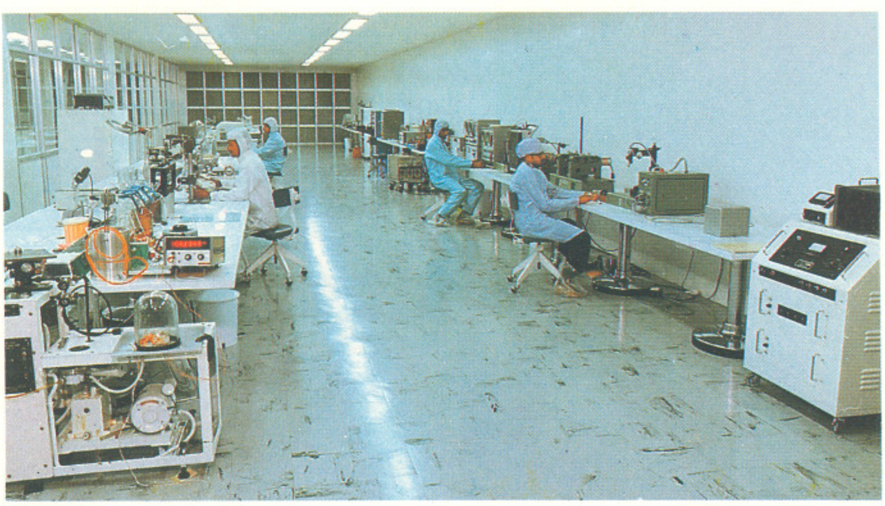
Supervised digital classification of IRS LISS-II data over Kaziranga National Park in Assam showing land cover types.

Inertial Systems for Space

Any physical measurement needs a coordinate system or a reference frame. In a laboratory on earth one could define a coordinate system with one axis along the vertical and the others in two horizontal but mutually perpendicular directions. But when measurements are to be made in a rocket or a satellite, one uses an inertial reference system. By definition an inertial reference system is one in which Newton's laws of motion are strictly valid. A convenient inertial frame is one which has its origin at the centre of the earth and its axes oriented towards distant stars.

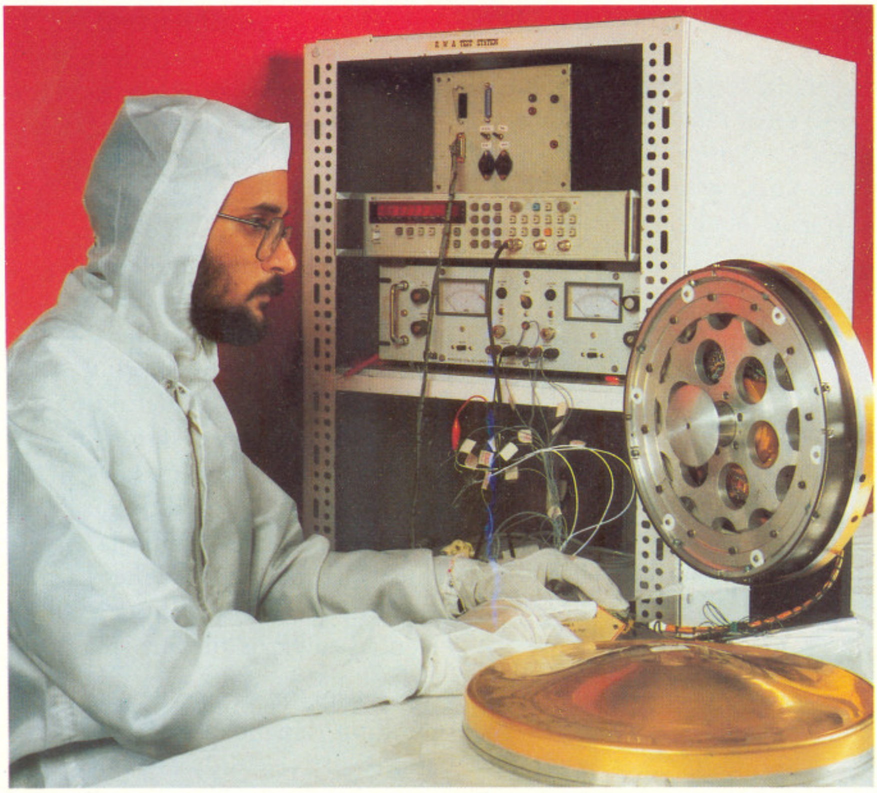
Any sensor or device whose operation depends on the validity of Newton's laws of inertia (and other related conservation laws) can be called an inertial device. An example is the accelerometer which measures force on a given mass. From measured acceleration, one can derive information on velocity and position by successive integrations.

Dynamically tuned Gyroscope

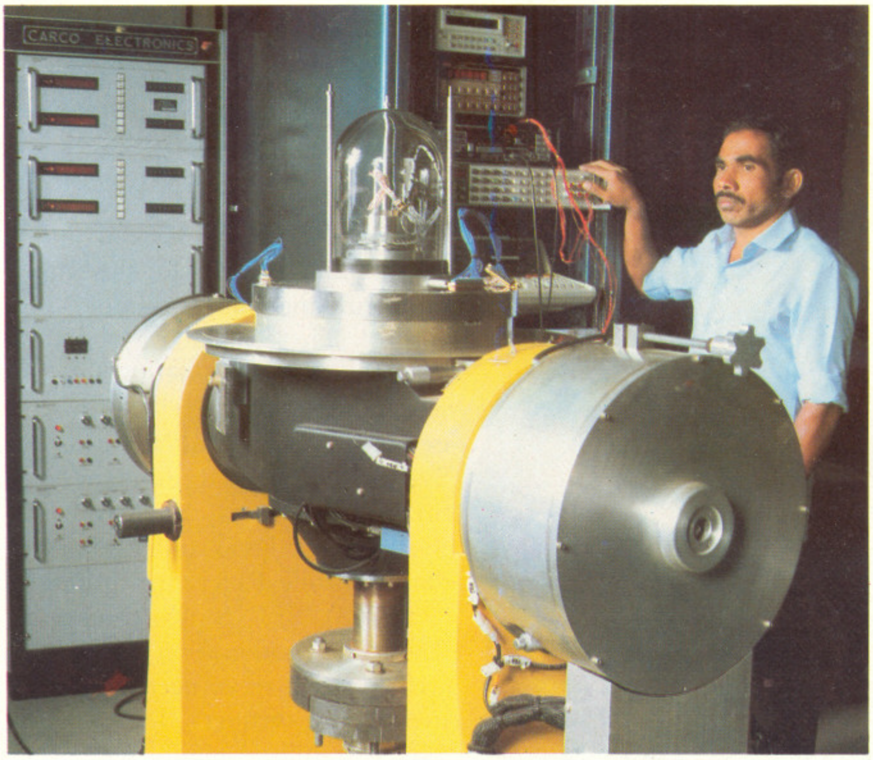


A view of the super clean room at VSSC when inertial systems were fabricated

Over the years, ISRO has developed a variety inertial sensors and systems for navigation, guidance and attitude control. These include gyros, accelerometers, momentum wheels, reaction wheels, Stabilised Platform Inertial Navigation System (SPINS), Redundant Strapdown Inertial Navigation System (RESINS) and Redundant Attitude Reference System (REARS). SPINS uses three floated rate integration gyros (RIG), three servo accelerometers and torquers. It is a 3-axis, stabilised platform based, inertial navigation system providing instantaneous position, velocity and attitude about three principal axes of a launch vehicle. RESINS is a strap-down inertial navigation system which provides redundant



Testing of a momentum wheel assembly which will be used on INSAT-II Test Spacecraft

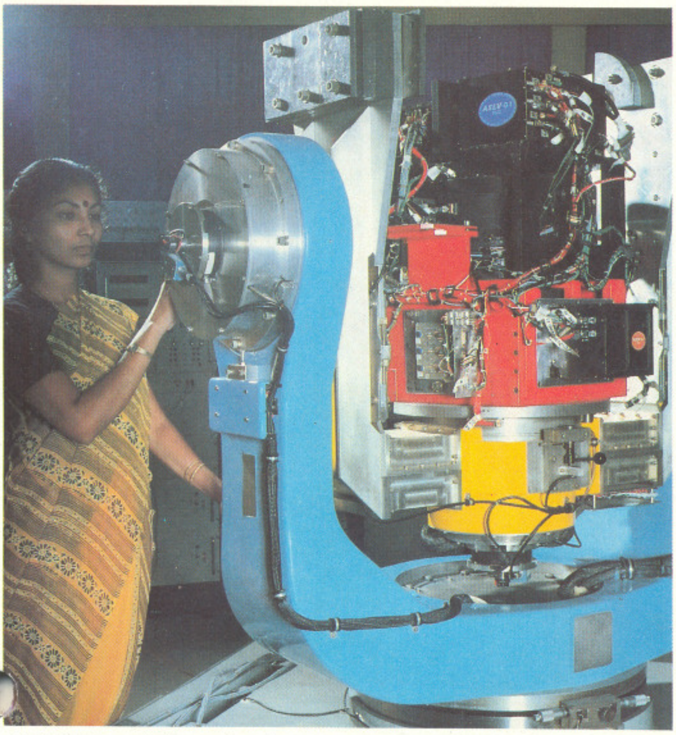


Performance testing of a dynamically tuned gyro

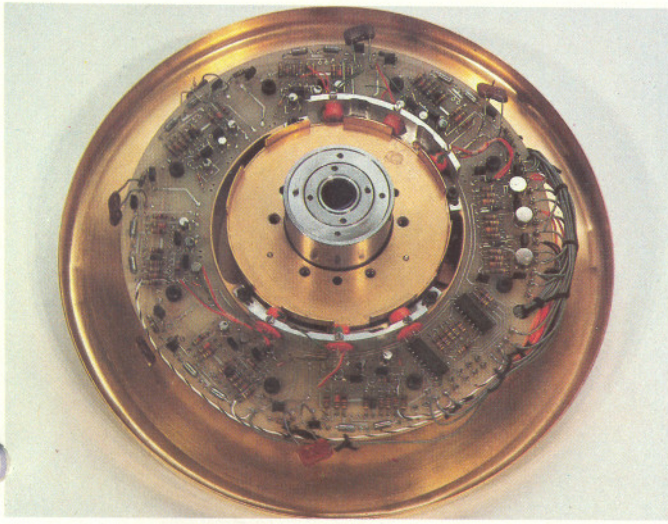
position, velocity and attitude information of a launch vehicle. It uses three Dynamically Tuned Gyros (DTG) and four force balance type, flextural pivot suspended servo accelerometers. REARS is a spacecraft attitude reference system and uses DTGs. The momentum and reaction wheels comprise high precision wet lubricated ball-bearing units, DC motors and fly wheels, all housed in a hermetically sealed casing. Precision pointing and attitude control of spacecraft are achieved using such wheels.

The inertial systems developed in ISRO incorporate some of the most advanced technologies in terms of materials, precision fabrication and assembly. The designs employ weight and volume optimisation, and provide a high degree of reliability and performance under stringent environs of space. For example the reaction wheels, the inertial reference unit using DTGs etc., have been successfully operating for over a year controlling the orbit and maintaining the precise orientation of the IRS-1A spacecraft. Thousands of high quality imageries obtained from IRS-1A are indicators of the performance of these systems in space.

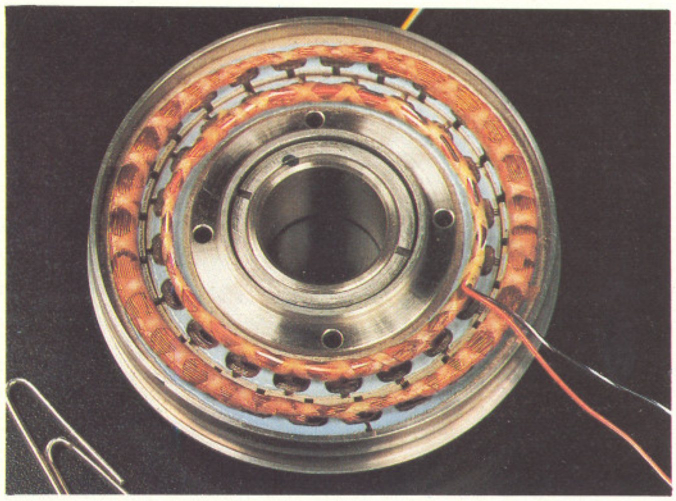
In pursuance of ISRO's policy to utilise the infrastructure and capability in the Indian industry to the maximum extent, the interest and feasibility of production of ISRO's inertial systems by the industries are being explored to meet the needs of future programmes. □



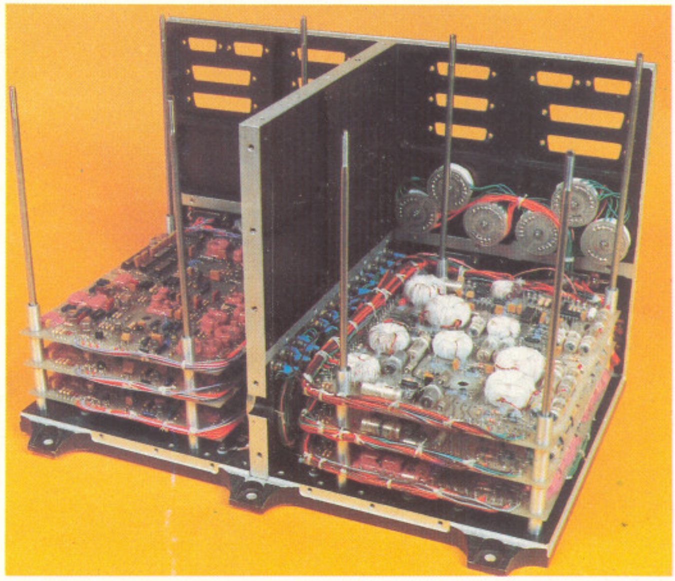
ASLV inertial navigation system on the three axis angular motion simulator



Momentum Wheel Electronics

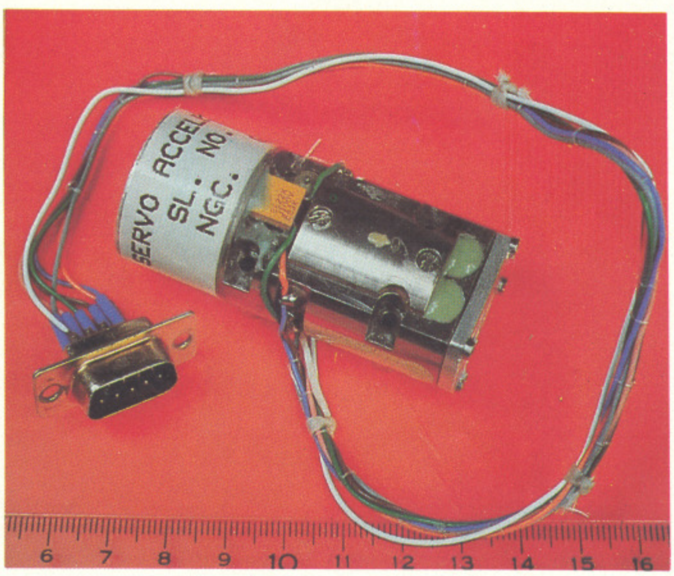


Gimbal resolver of the SPINS



The electronics module of the Redundant Strapdown Inertial Navigation System

A Servo accelerometer used for the measurement of linear acceleration of launch vehicles.



A PEP for Rockets

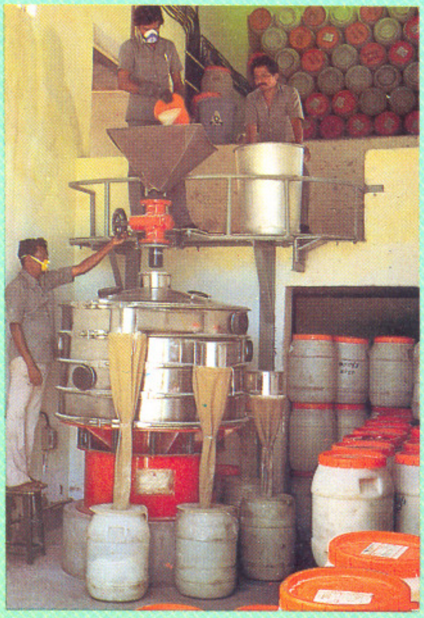
Alwaye is a small town 25 km east of the port city Cochin in the State of Kerala. For years it was known mainly for the religious festivals on the serene banks of the Periyar river. Ten years ago, in February 1979, the Vikram Sarabhai Space Centre (VSSC) at Trivandrum extended its wings to this little known place by setting up an experimental chemical plant on a 22 hectare industrial site. Today Alwaye boasts of one of the most modern chemical plants in the world producing Ammonium Perchlorate of the propellant grade.

It is well known that, unlike an aircraft, a rocket needs to carry its own oxidiser in addition to the fuel needed to lift it up into space. Ammonium Perchlorate forms the oxidiser in solid propellants used in ISRO sounding rockets and satellite launch vehicles. Named as Ammonium Perchlorate Experimental Plant (APEP), the Alwaye plant is designed and built with completely indigenous technology. The Central Electro-chemical Research Institute (CECRI) at Karaikudi originally developed the laboratory process which was later modified and scaled up to an operational plant scale by VSSC for use in ISRO's rocket programmes. The plant is so designed that it can form a nucleus for the manufacture of other electro-chemicals such as perchloric acid, potassium perchlorate, magnesium perchlorate and strontium perchlorate.

Manufacture of propellant grade Ammonium Perchlorate involves a sequence of operations which are closely controlled. The processes involved are elctrolysis, double decomposition, vacuum filtration, recrystallisation and drying. In order to achieve the required chemical purity and the particle shape and size of the final product, it is essential to employ stringent quality control measures at each step.

APEP comprises an anode house, a cell house, a process house and a drying house. At the anode house Titanium Substrate Lead Dioxide anodes are prepared. The modular cells of cell house use the Titanium Substrate Lead Dioxide anodes produced at the anode house and stainless steel cathodes. The cell house

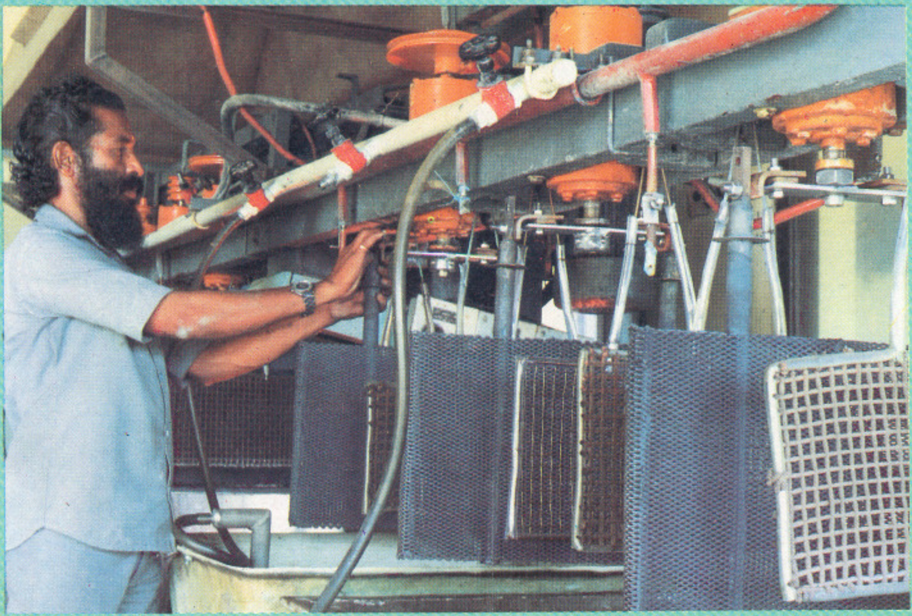
Classification of Ammonium Perchlorate grains



The Alwaye Ammonoium Perchlorate Experimental Plant

produces sodium perchlorate by electrolytic oxidation of sodium chlorate, which is the starting material. In the process house sodium perchlorate is double-decomposed with ammonium chloride to obtain Ammonium Perchlorate. At the drying house the process is completed by removing the moisture and classifying the final product into different particle sizes. The fractions are then blended in specified proportions and packed in airtight containers.

Besides the essential quality control provisions this plant has meticulously planned safety and pollution control measures required at such chemical plants. It is capable of producing 220 tonnes of Ammonium Perchlorate annually. The capacity could be doubled if needed. □



Preparation of Titanium Substrate Lead Dioxide anodes at APEP

An inside view of APEP

A view of the electrolytic cells at the cell house

Ammonium Perchlorate Data Sheet Specifications (Typical)

Assay, min (%)	99.00
Chloride, max (%)	0.07
Chlorate, max (%)	0.08
Sulphate, max (%)	0.05
Sulphate Ash, max (%)	0.25
Water insolubles, max (%)	0.01
Surface moisture, max (%)	0.08

AN MOU THAT LAUNCHED A THOUSAND ROCKETS

Academician Yu.A.Izrael (left), Head of the USSR Committee on Hydrometeorology and Prof. U.R.Rao exchanging copies of the Agreement

Indo-Soviet collaboration in space meteorology and aeronomy was initiated through a Memorandum of Understanding (MOU) in 1970. Under this programme sounding rockets are launched regularly at weekly intervals for intensive study of the atmospheric temperature, pressure and winds upto about 80 km altitude. The synoptic data set collected over India, along with similar data collected from other locations over USSR and Antartica, have been utilised to derive the climatic standards for different latitudinal regions of the globe.

Starting from December 1970, when the first Soviet M-100 rocket zoomed upwards from the shores of the Thumba Equatorial Rocket Launching Station (TERLS), the rocket-a-week launches have become a part of normal life for the people of Trivandrum. So it was when another M-100 rocket took off on June 8, 1988. However for the scientists, engineers, technicians and other staff at Thumba this was a special day — the day that saw the launch of 1000th M-100 rocket from TERLS.

Later, on January 18, 1989 an inter-governmental agreement between India and USSR on scientific and technical cooperation in the field of meteorological and upper atmospheric research using space techniques was signed at Bangalore. In addition to consolidating and strengthening the already existing collaboration, this agreement provides a broader base for cooperative research including new areas such as climatic changes brought about by anthropogenic sources, effects of atmospheric pollution, cyclone energetics and monsoon studies. These are considered to be of great importance in gaining a better understanding of the global ecological problems.

The first protocol for joint research was signed by the Indian Department of Atomic Energy and the Hydro-meteorological Services (HMS) of the USSR. Later HMS came to be known as the USSR State Committee for Hydrometeorology and Control of Natural Environment (SCHCNE). Now the same organisation has been renamed as the USSR State Committee on Hydrometeorology. Since the formation of the Department of Space (DOS) and the Indian Space Research Organisation (ISRO) the scope of the joint investigation has been continuously expanded. From 1979 Indian RH-200 rockets are also being launched at weekly intervals from Balasore for synoptic studies of atmospheric processes. More than 500 such rockets have so far been launched in this programme. □

Assembly of an M-100 rocket at TERLS

An M-100 rocket on the launch pad.

Areas of Cooperati

— study of atmospheric processes in the tropical zone and their relationship to the high latitude processes;

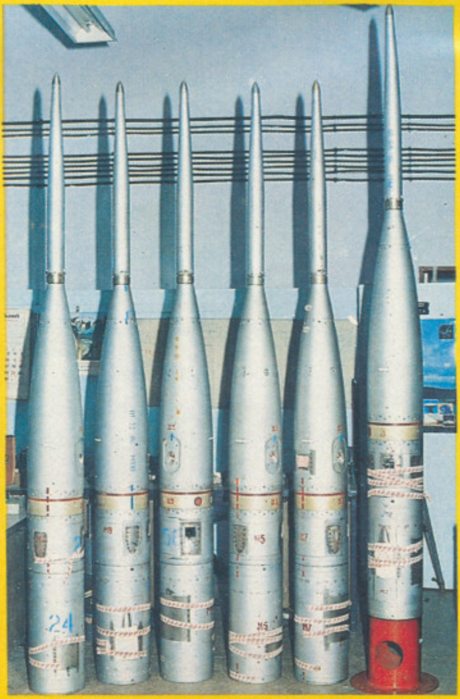
— study of tropical cyclone structure, energetic and conditions of their genesis, improvement of existing and creation of new fore-casting methods of their development and trajectories of motion;

— conducting systematic studies of the upper atmos-phere and ionosphere using ground-based instruments as well as rocket and space-based facilities;

— study of the variations of ozone and minor constituents in the tropical atmosphere and their global implications;

— study of variability of the middle atmosphere of equatorial; tropical and high

M-100 rocket payloads ready for integration



Research

latitude zones and definition of climatic norms;

— study of ionospheric structure and specific features of wave propagation in the ionosphere of tropical zone, organisation of receiving and transmitting stations for oblique incidence ionospheric sounding;

— conduct of ground and space based investigations of biospheric and atmospheric pollution;

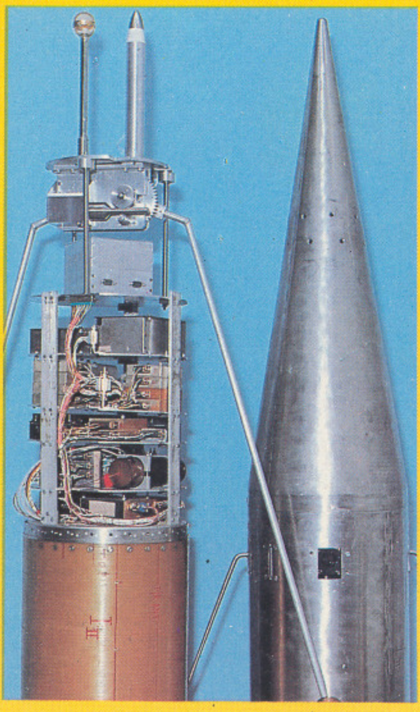
— conduct of complex experiments of modification of atmospheric processes in the tropical zone;

— monsoon study and forecasting;

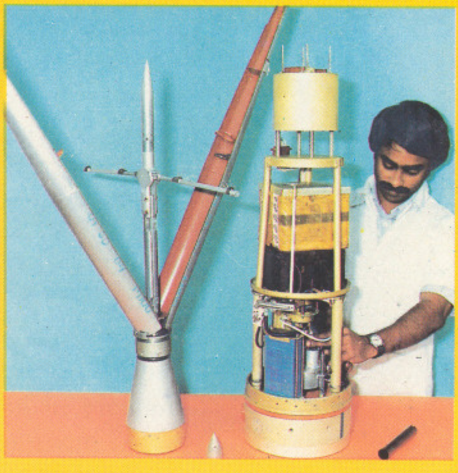
— study of anthropogenic changes of climate;

— forecasting of crops state and productivity.

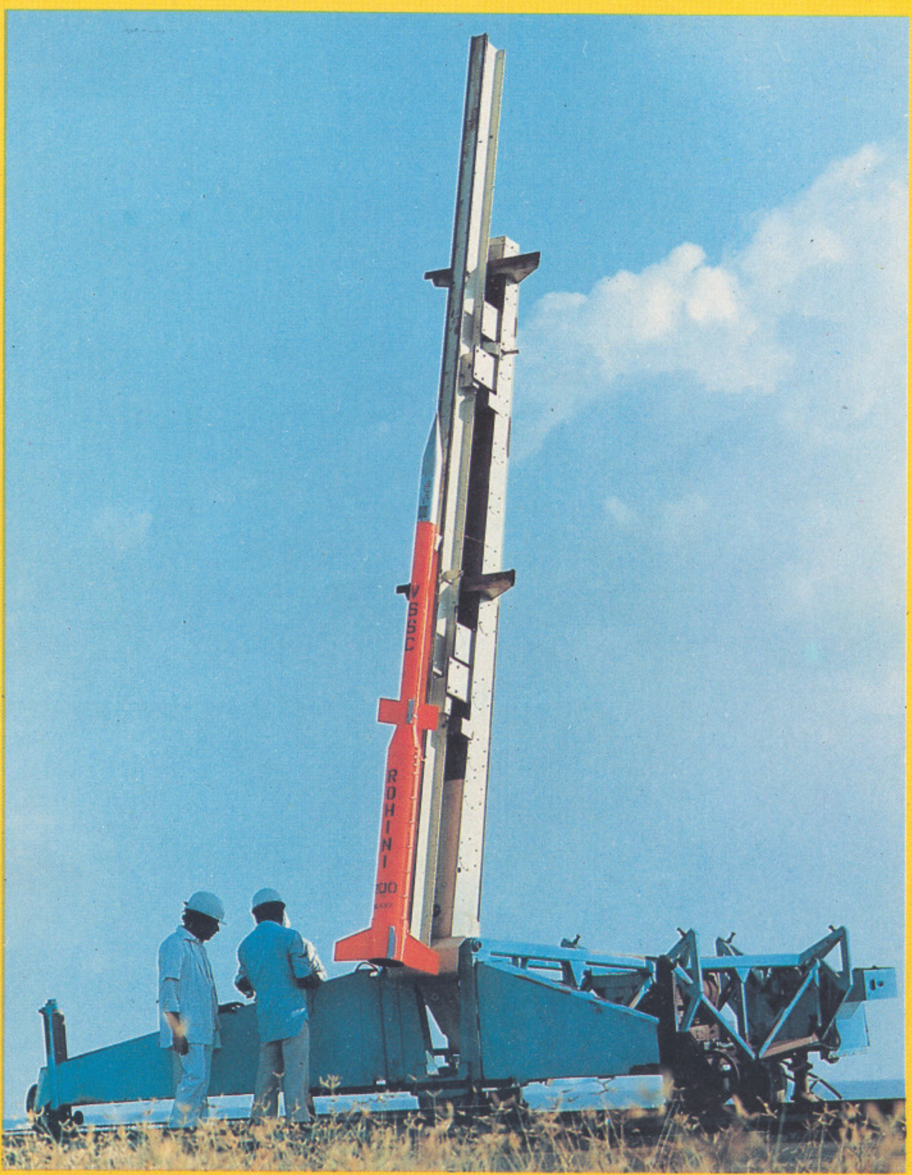
Mechanical integration of the payloads



Scientific Payloads flown on M-100 Rockets



RH-200 rocket on the launch pad



New Space Headquarters

Anthariksh Bhavan

The headquarters of the Department of Space (DOS) and the Indian Space Research Organisation (ISRO) are now located in a building of their own — at last. From the hired nine storey eastern wing of the Cauvery Bhavan, on the busiest commercial spot in Bangalore, it has been a much awaited move to the calm and quiet Nagasettyhalli. The three floor and three wing Anthariksh Bhavan, was inaugurated by Prof. U.R.Rao, Chairman, Space Commission and Secretary, Department of Space on March 2, 1989 with a formal ribbon cutting ceremony.

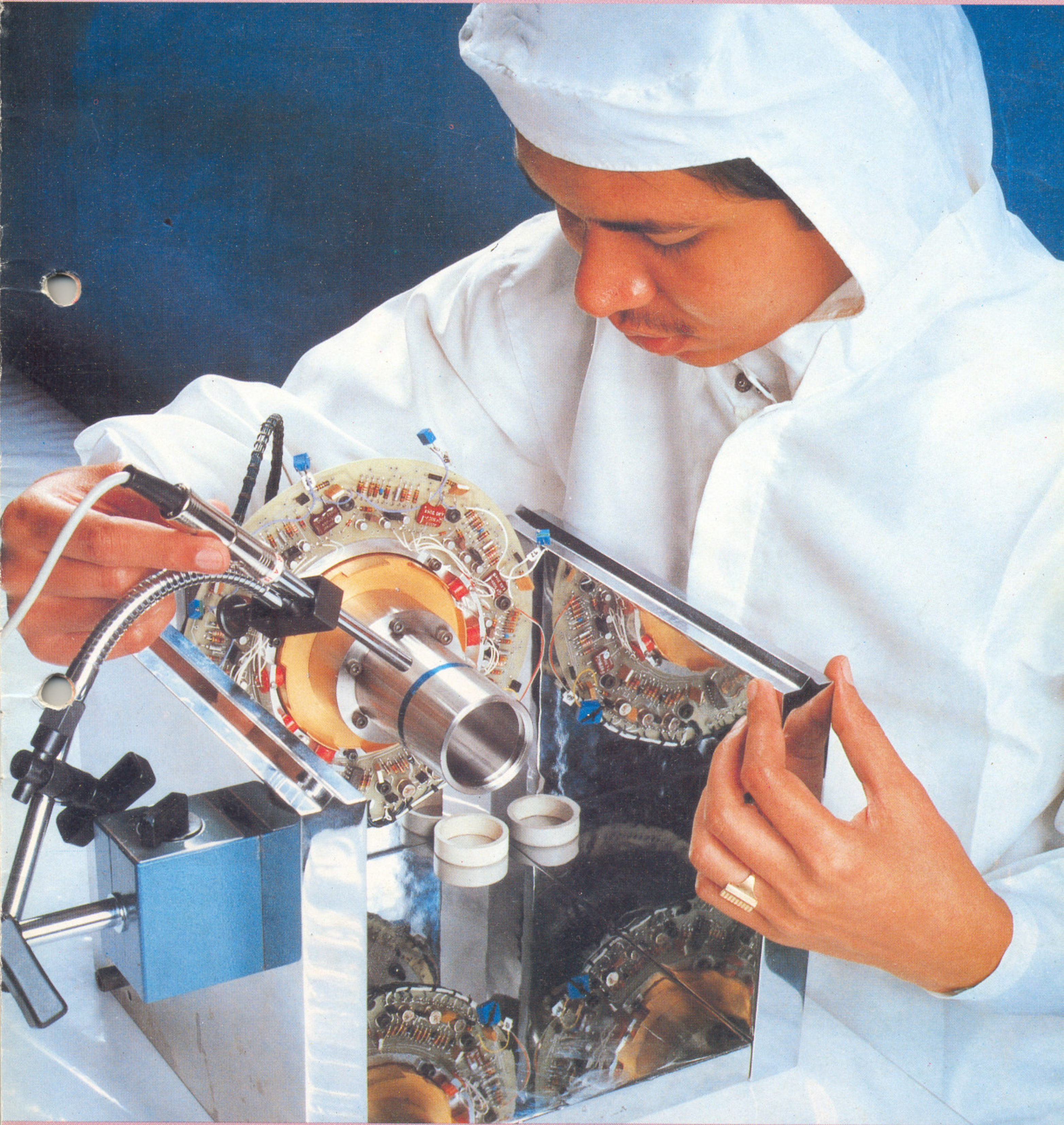
Actual shifting of the offices was by no means an easy task. But the ever-resourceful staff at the HQ rose upto the task in the usual way. The dust is now settling down and the telecommunications are gradually coming to life. Soon it will be sun shine and routine, notwithstanding the twenty odd kilometers from the airport and the Satellite Centre.

Our New Address:

'Anthariksh Bhavan'
New BEL Road, Bangalore 560 054
Telephone: 0812-334474
Telex: 0845-2499 & 2326
Fax: 0812-334229

Inauguration of 'Anthariksh Bhavan" by Prof. U.R.Rao, Chairman, ISRO and Secretary, DOS

Reaction wheel bearing assembly test. Inertial systems for use in space demand highest production standards. Special clothing is worn to protect vital components from contamination by dust.



Anthariksh Bhavan , the new Space Headquarters at Bangalore