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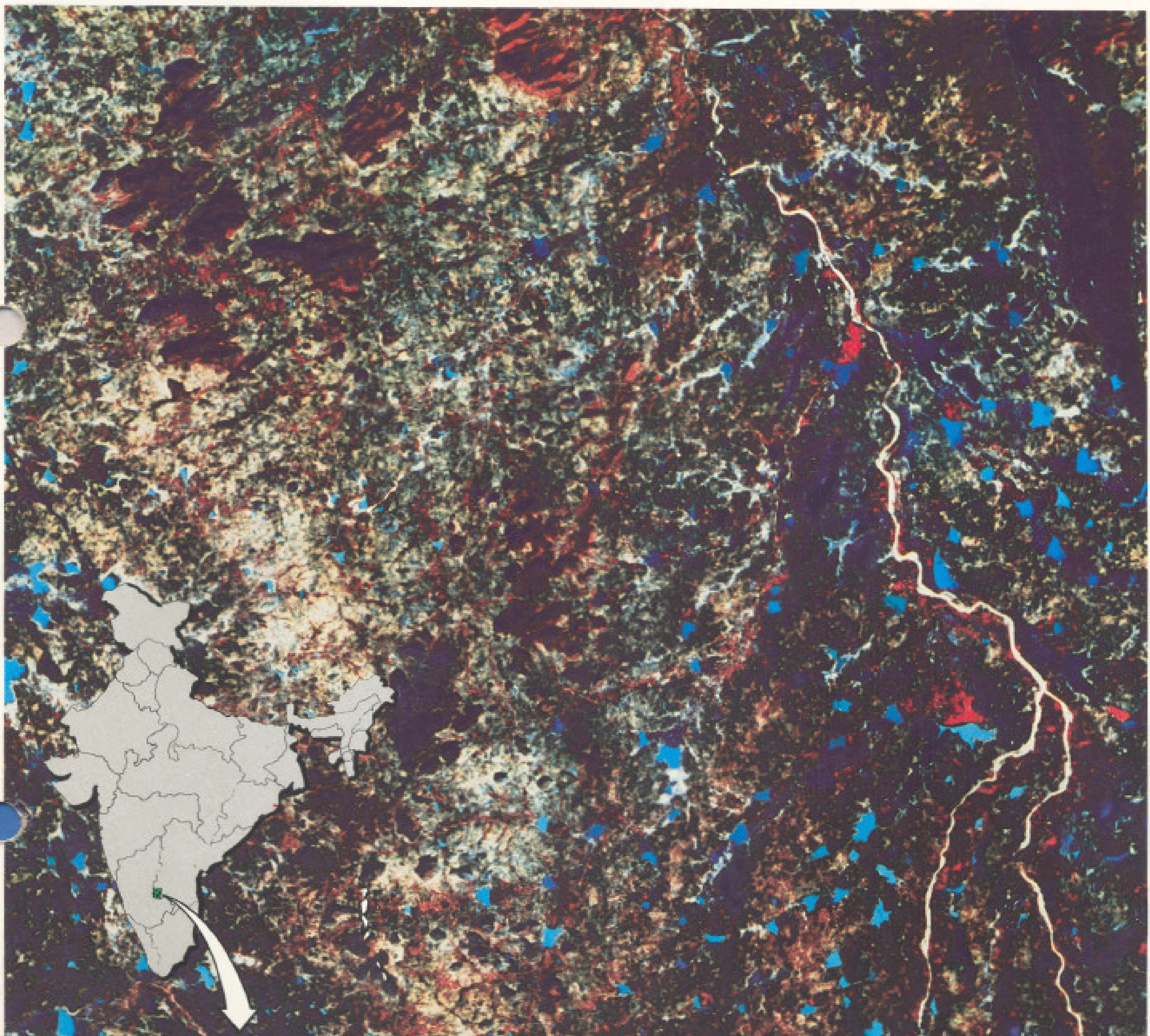
SPACE india



INDIAN SPACE RESEARCH ORGANISATION

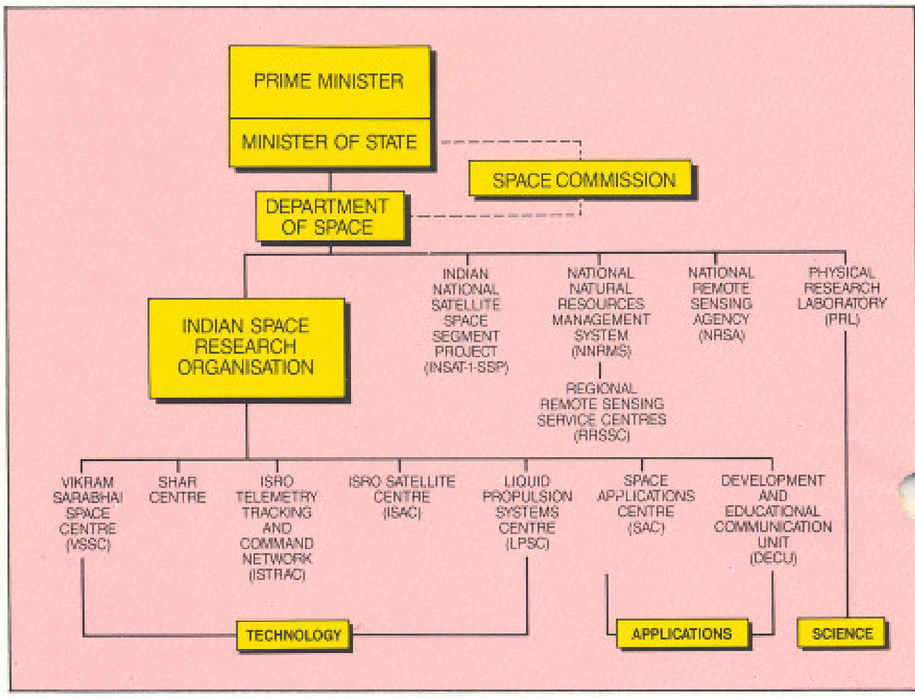
The Indian Space Programme

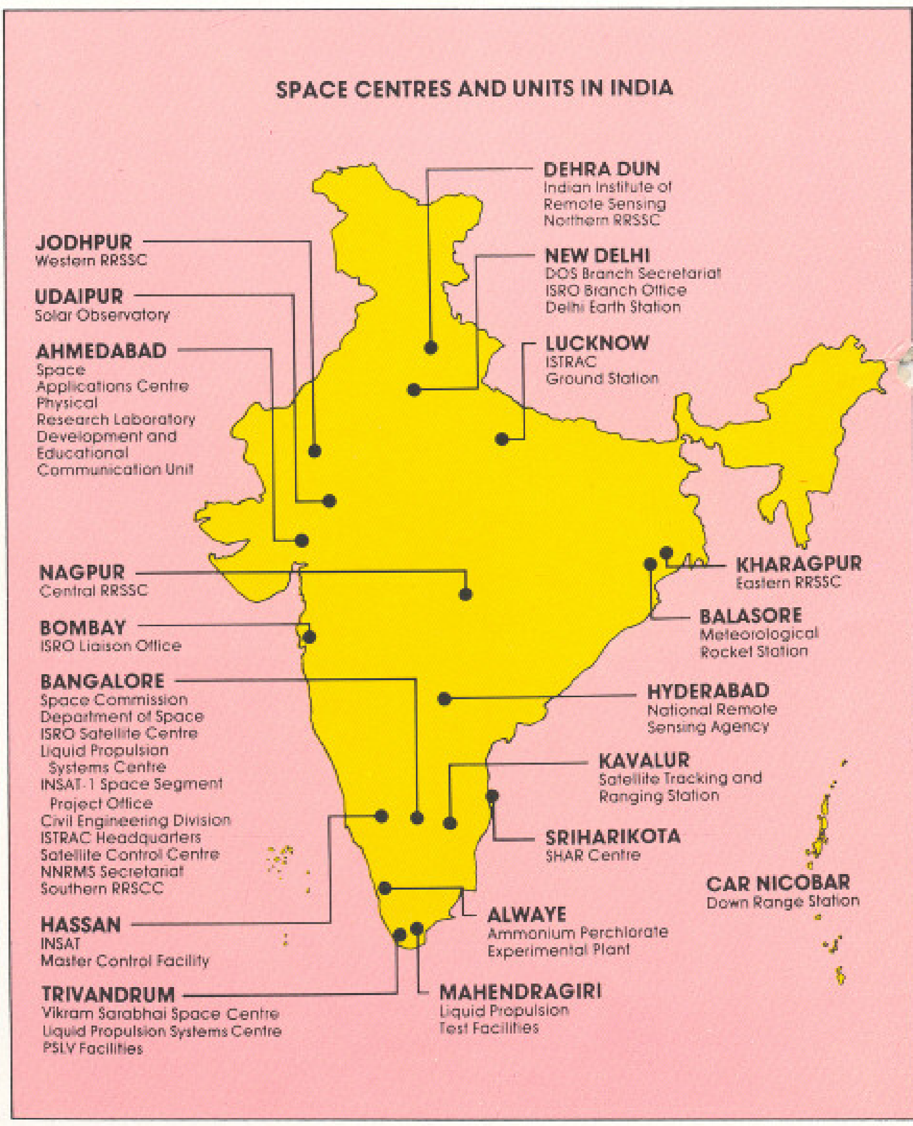
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science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

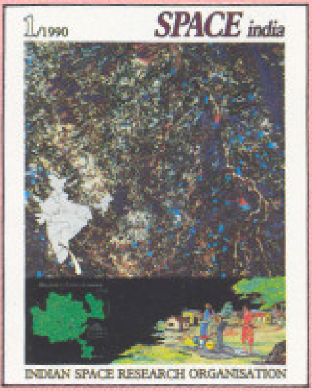
The Indian Space Programme is directed towards the goal of self-reliant use of space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological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

Satellite data for ground water mapping

EDITORS

S. Krishnamurthy
Manoranjan Rao

EDITORIAL ASSISTANCE

S.K. Dutta

PRODUCTION ASSISTANCE

B. Chandrasekhar

Contents

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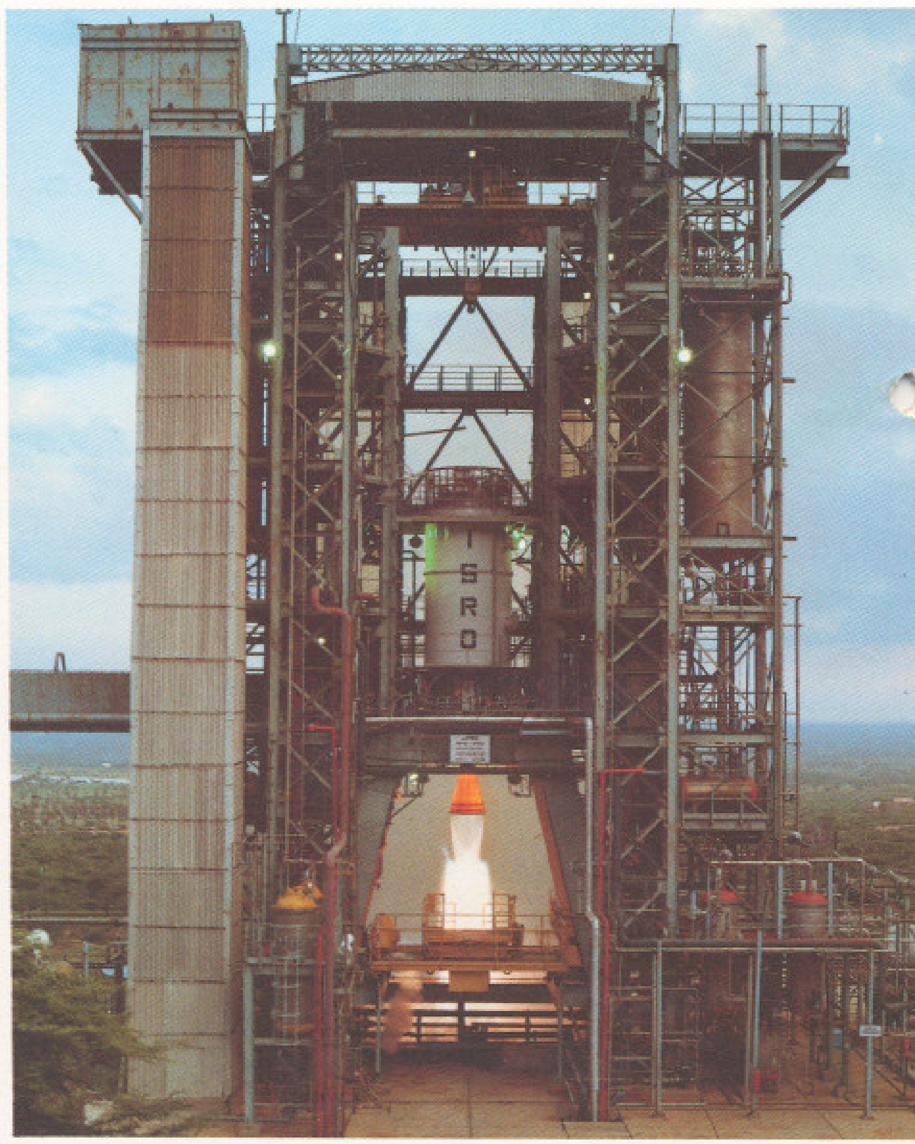
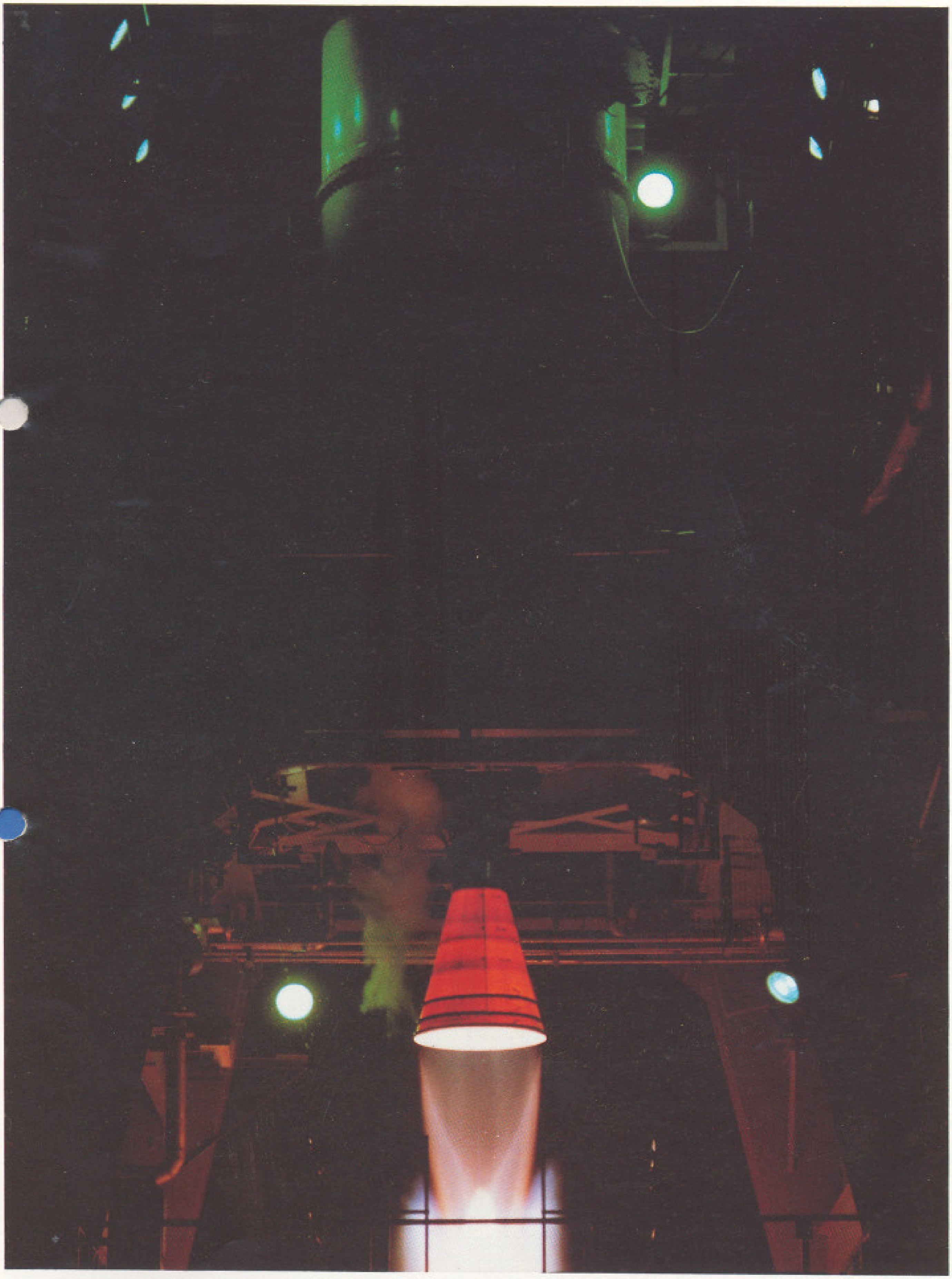
PSLV Second Stage Successfully Tested

The battleship version of the Polar Satellite Launch Vehicle (PSLV) second stage (PS-2) was successfully tested on March 21, 1990 at the Liquid Propulsion Test Facility, Mahendragiri. The battleship version of the stage is identical to the flight configuration except that the tankage is made out of stainless steel (instead of aluminium alloy to be used in flight) and the nozzle is of sea level version. All the performance parameters of the stage were within specified limits during the test.



The second stage of PSLV, 2.8 metres in diameter and 11.5 metres in length, uses 37.5 tonnes of the liquid propellants, Unsymmetrical Di-Methyl Hydrazine (UDMH) and Nitrogen Tetroxide (N_2O_4). The stage develops 60 tonnes of thrust at sea level and burns for 150 seconds. During the PSLV flight, PS-2 which is ignited at an altitude of about 50 km, propels the rest of the PSLV stages including the satellite to an altitude of about 200 km.

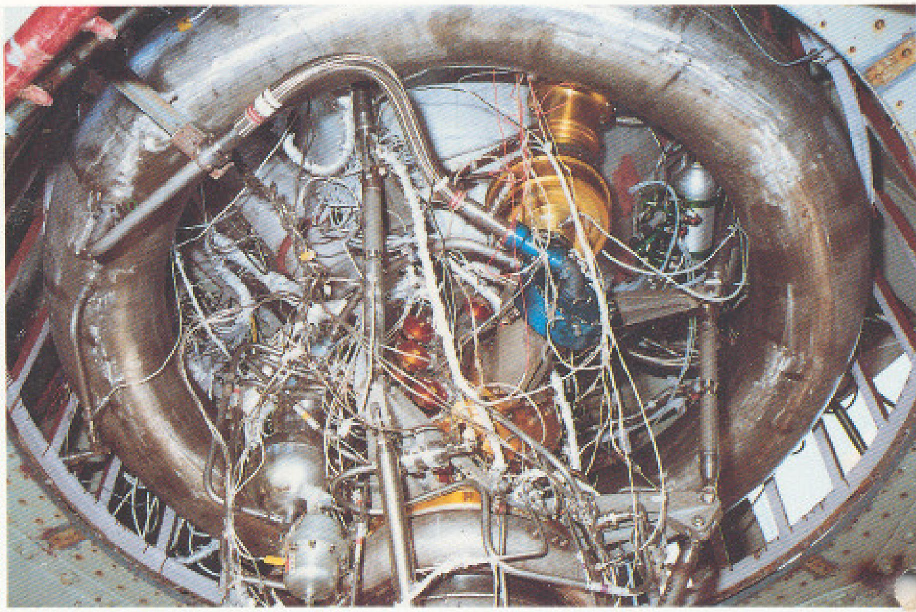
While the second stage engine (VIKAS) had already been fully



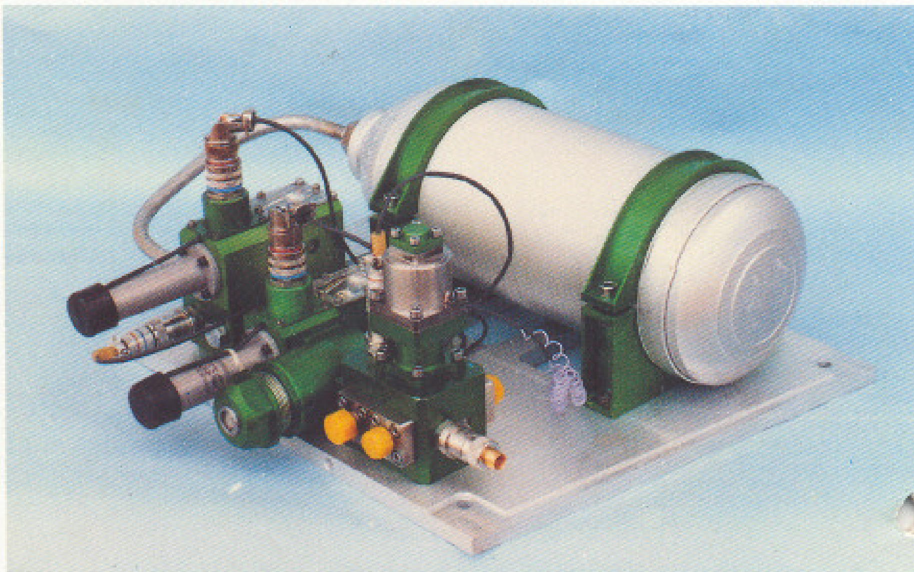
PS-2 Battleship test in progress.(left and above) tested earlier, the present test has qualified the entire stage, including the Gimbal Control System of the engine. PS-2 is the largest liquid propulsion stage developed in the country.

The engine, operating at a chamber pressure of 52.6 bars with a nozzle area ratio of 31, gives a Specific Impulse of 293 sec. (nominal). The propellants from the tanks are fed to the combustion chamber at the rate of about 251 kg/sec. (at 65 bars nominal pressure) by a turbo pump system, driven by a turbine rotating at 9,600 rpm. The turbine is driven by the hot gas from a gas generator, which also works on the same propellant combination as that of the engine. The gas generator combustion gases are cooled to about 600 deg.C by spraying water inside the gas generator. The engine is controlled by a two-stage feed back regulation system. The combustion chamber is film and sweat cooled by part of the fuel. The engine is gimballed in two planes to achieve pitch and yaw control of PSLV during PS-2 operation. The propellant tank is of a common bulk head construction with N_2O_4 in the top compartment and UDMH in the bottom compartment. The tank compartments are provided with slosh suppressors to avoid the oscillation of the propellants during flight. The toroidal water tank is located below the propellant tank. The thrust frame of sheet stringer construction transmits the engine thrust to the stage.

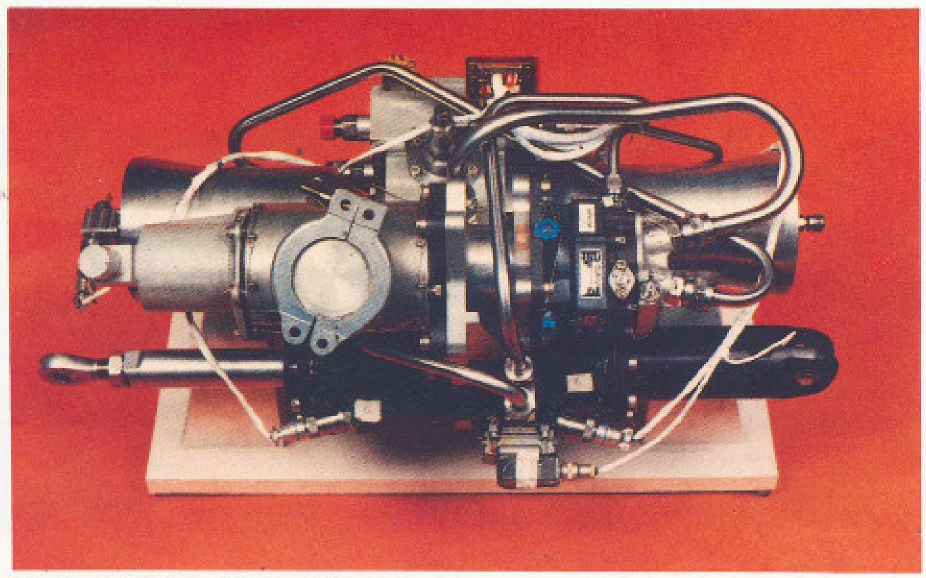
Propellant and water for the gas generator are pressurised by Helium (to ensure a positive suction pressure at the entry to the pumps) stored in four high pressure spherical titanium-alloy bottles. The pressurisation system include pressure regulators and valves for filling, venting and



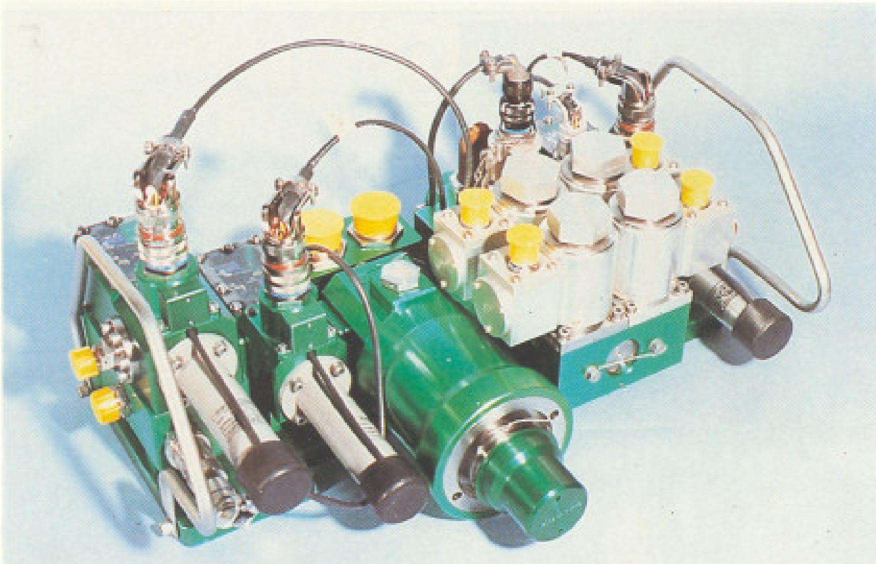
Propulsion bay.



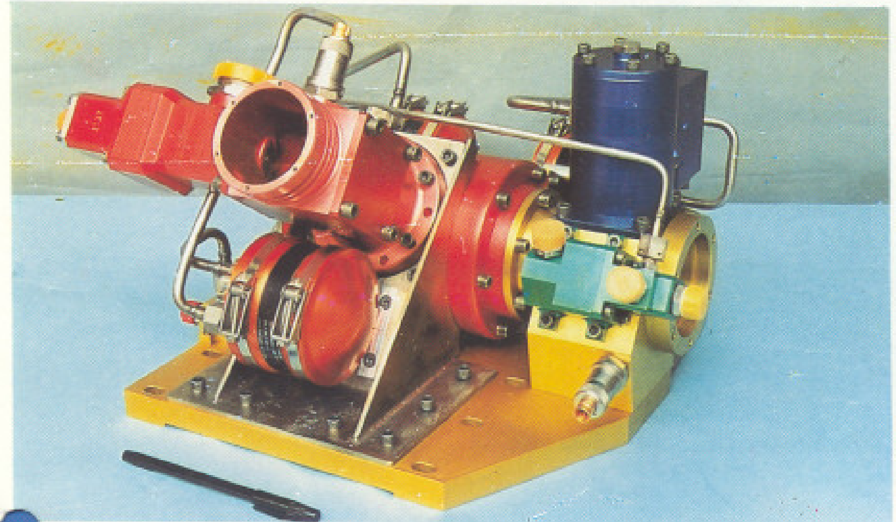
Pogo command module.



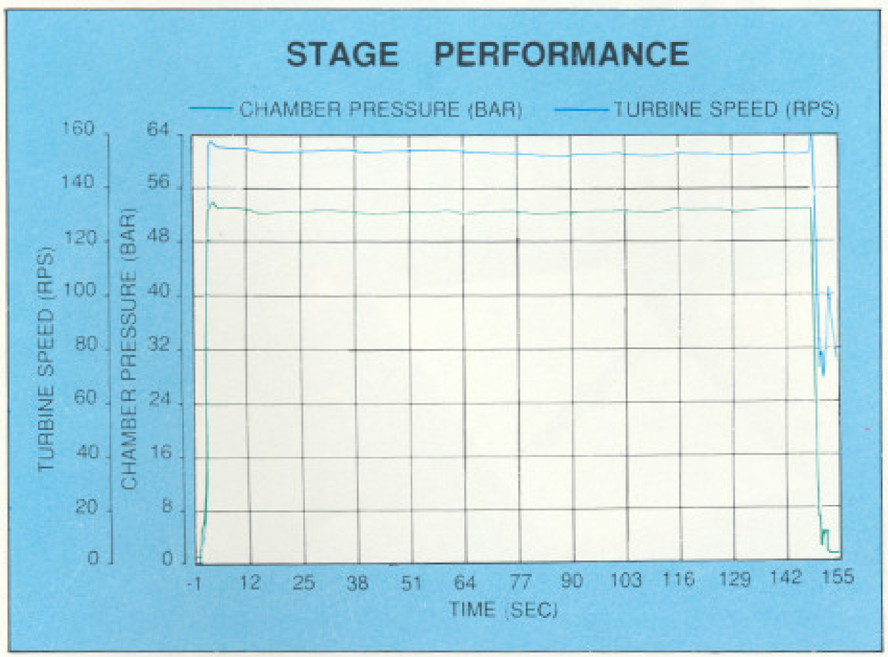
Engine gimbal control module.



Command module.



Pressurisation module.



starting, and over-pressure protection and reverse flow prevention mechanisms.

The Stage Command system provides start and stop commands to the engine and pneumatic reference pressure for actuating the regulators and valves. It comprises gas bottle and command module housing valves and regulators.

The Pogo Corrector system suppresses any unstable low frequency longitudinal vibration of PSLV during the operation of PS-2. One Pogo Corrector is mounted on each propellant feed line and is provided with regulated stored Nitrogen gas as and when required.

The attitude of PSLV during the operation of PS-2 is controlled by gimballing the engine in two planes; the Gimbal Control system is commanded by the vehicle autopilot. The gimballing system consists of electro-hydraulic actuators with integrated hydraulic power supply and electronics. The prime mover of this package is a hot gas motor connected to gas generator through a thermal regulator, hot gas filter and commutator and is capable of delivering 10 hp power to the package. The package uses stored hydraulic power from an accumulator for initial positioning of the engine before gas generator power is available. The Roll Control system comprising thrusters using hot gas bled from the gas generator develops 300 N thrust.

Coming closely on the heels of the successful static test of PS-1, the satisfactory testing of the Battleship version of PS-2 marks another major milestone in the development of PSLV.

Stage Systems

Engine

Tankage, Thrust frame and Interstages

Pressurisation system

Command system

Fill and Drain system

Feed, Purge and Flush system

Pogo Corrector system

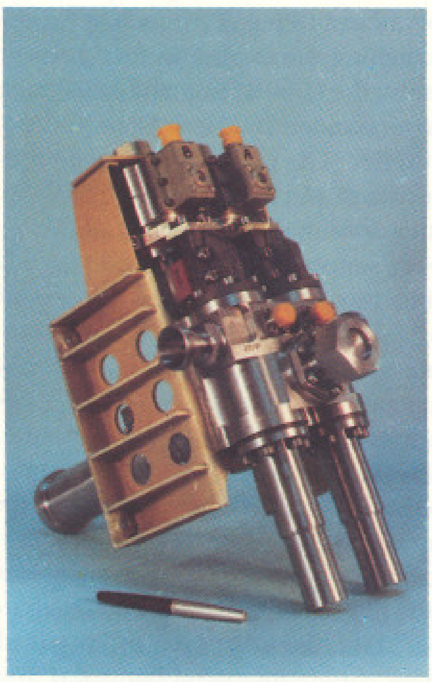
Gimbal Control system

Roll Control system

Pneumatic Umbilical system

Slosh suppressors. □

Vikas engine.



Hot gas roll control system.

ISRO Bids For INMARSAT

ISRO has submitted a comprehensive proposal to the International Maritime Satellite Organisation (INMARSAT) for building the third generation INMARSAT satellites, in response to the Request For Proposals (RFP) issued by INMARSAT. This was the result of an intense exercise carried out by a large team of technical and managerial experts in ISRO over the last four months (October 1989 to January 1990). ISRO has also submitted its bid for the Satellite Ground Control System (SGCS) which has been sought as an option by INMARSAT.

INMARSAT, set up in 1979, began operating a maritime communication network in 1982. The organisation now serves the land and aeronautical markets as well, besides its traditional domain of sea. INMARSAT has 58 Member-States at present.

The current space segment of INMARSAT consists of leased spacecraft/transponders from agencies such as ESA, INTELSAT and COMSAT. British Aerospace is the prime contractor for the second generation INMARSAT spacecraft which are to be launched starting in the second half of 1990. The third generation spacecraft are planned to be launched beginning in 1994.

The proposal by ISRO for building INMARSAT-3 satellites comes in the light of maturity ISRO has attained in satellite technology and the strong infrastructure it has built in this field. This has been well demonstrated by the realisation of state-of-the-art operational remote sensing satellite IRS-1A which has proved it's mettle in orbit during the last two years, and the fabrication of INSAT-II Test Spacecraft which has made substantial progress.

The multi-million Dollar contract for INMARSAT-3 Spacecraft is expected to be finalised before the end of the current year. □

The Proposals.

IRS-1A Completes Two Years

The Indian Remote Sensing Satellite, IRS-1A, completed two years of successful operation in orbit on March 17, 1990. The state-of-the-art remote sensing satellite is providing operational services of vital interest to our country in many areas such as optimal utilisation of water, land and forest resources. So far, IRS-1A has covered the entire country 32 times and has provided more than two lakh imageries. India is only the fifth country in the world and the first among the developing countries to have its own operational remote sensing satellite. IRS-1A is as advanced as any contemporary remote sensing satellite such as the US Landsat and the French SPOT satellite.

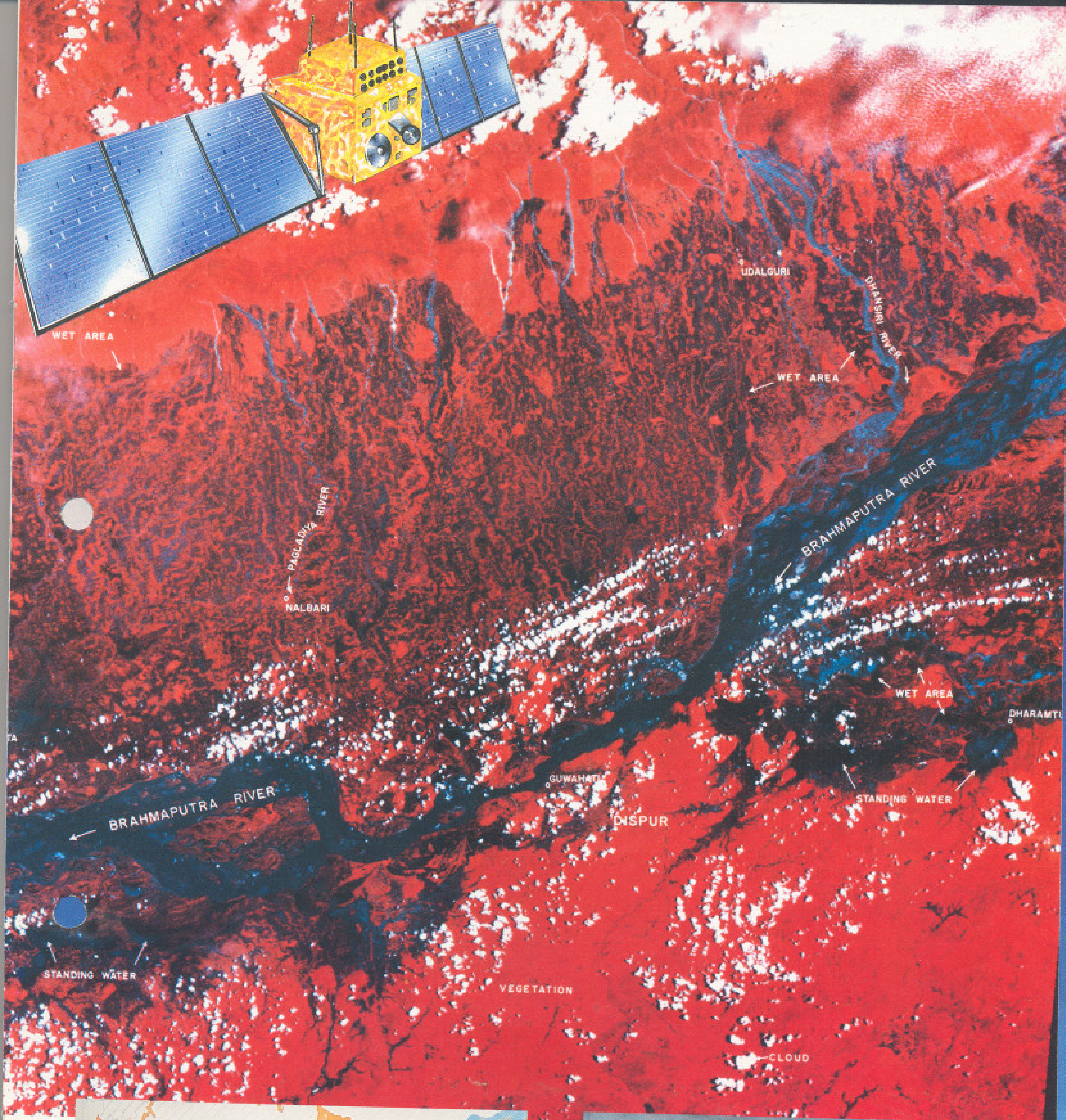
IRS-1A has become the mainstay of the National Natural Resources Management System (NNRMS) for which the Department of Space is the nodal agency. NNRMS is a unique system in which the conventional data sources are integrated with the space-based remotely-sensed data for effectively managing the natural resources of the country. IRS-1A has become a vital component in the national level projects like waste-land mapping, land-use mapping, forestry mapping, agricultural crop acreage and yield estimation, integrated drought management, water resources management including ground water targeting, flood mapping and management, mineral resource exploration, ocean development including coastal monitoring and mapping of marine and inland fisheries potential.

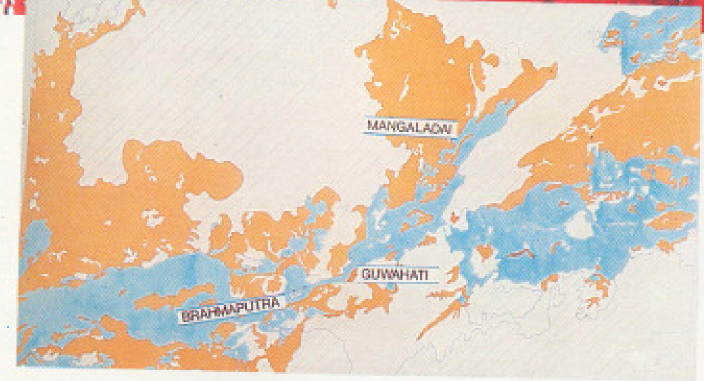
The Spacecraft Control Centre located at Bangalore, along with ground stations at Lucknow and Mauritius, regularly track, monitor and control the spacecraft. The spacecraft orbit and attitude are precisely controlled to enable imaging of pre-specified scenes. IRS-1A carries two advanced imaging sensors, namely, Linear Imaging Self Scanners (LISS-I and LISS-II) and has sophisticated systems for high bit rate image transmission, automatic payload operation, driven deployable sun-tracking solar panels, three-axis body stabilisation employing dry-tuned gyros, reaction wheels, scanning sensors and reaction control systems.

The data reception station of the National Remote Sensing Agency (NRSA) at Shadnagar near Hyderabad receives the data from IRS-1A in S-band and X-band. Data products generation is carried out through the facilities set up at NRSA, Balanagar, and at Space Applications Centre, Ahmedabad. The ground system facilities work round the clock to ensure supply of photographic and digital data products at various levels to more than 500 user departments/agencies in the country.

In addition to the five Regional Remote Sensing Service Centres (RRSSCs) set up by the Department of Space in different regions of the country, many State Governments have set up remote sensing application centres providing the necessary facilities for analysis of IRS-1A data and retrieval of various types of information.

The successful completion of two years by IRS-1A has demonstrated the indigenous capability for building and operating a state-of-the-art remote sensing system – both the space and ground segments. The country has thus established a strong base for providing operational satellite services for meeting the vital needs of the country in various sectors of development. □



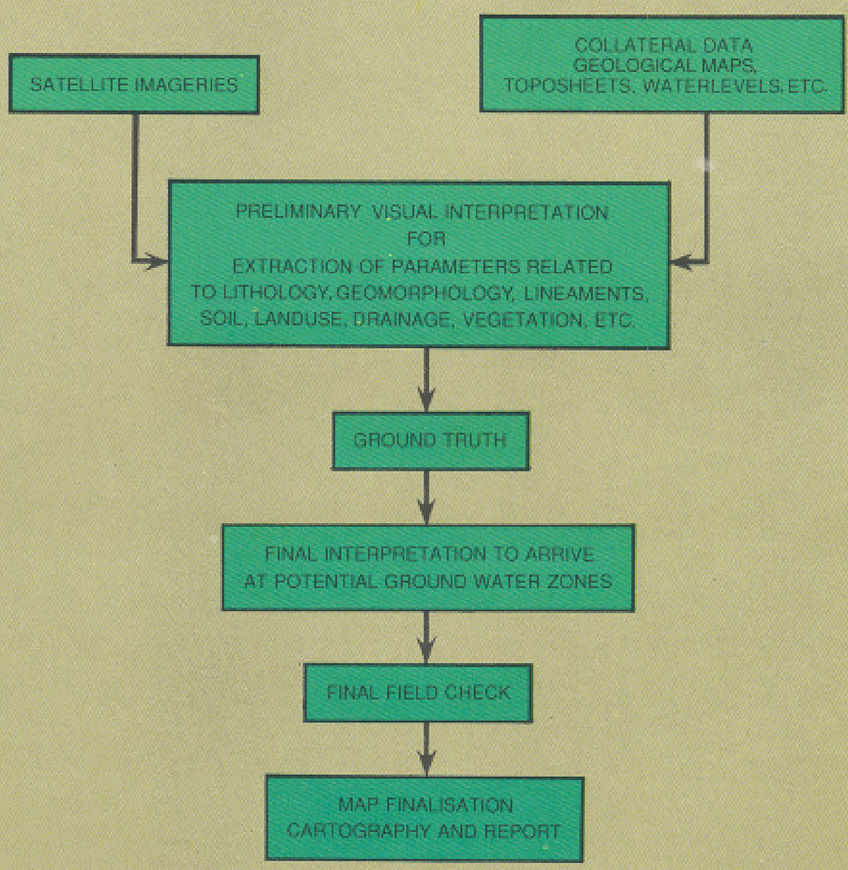


IRS and Flood management

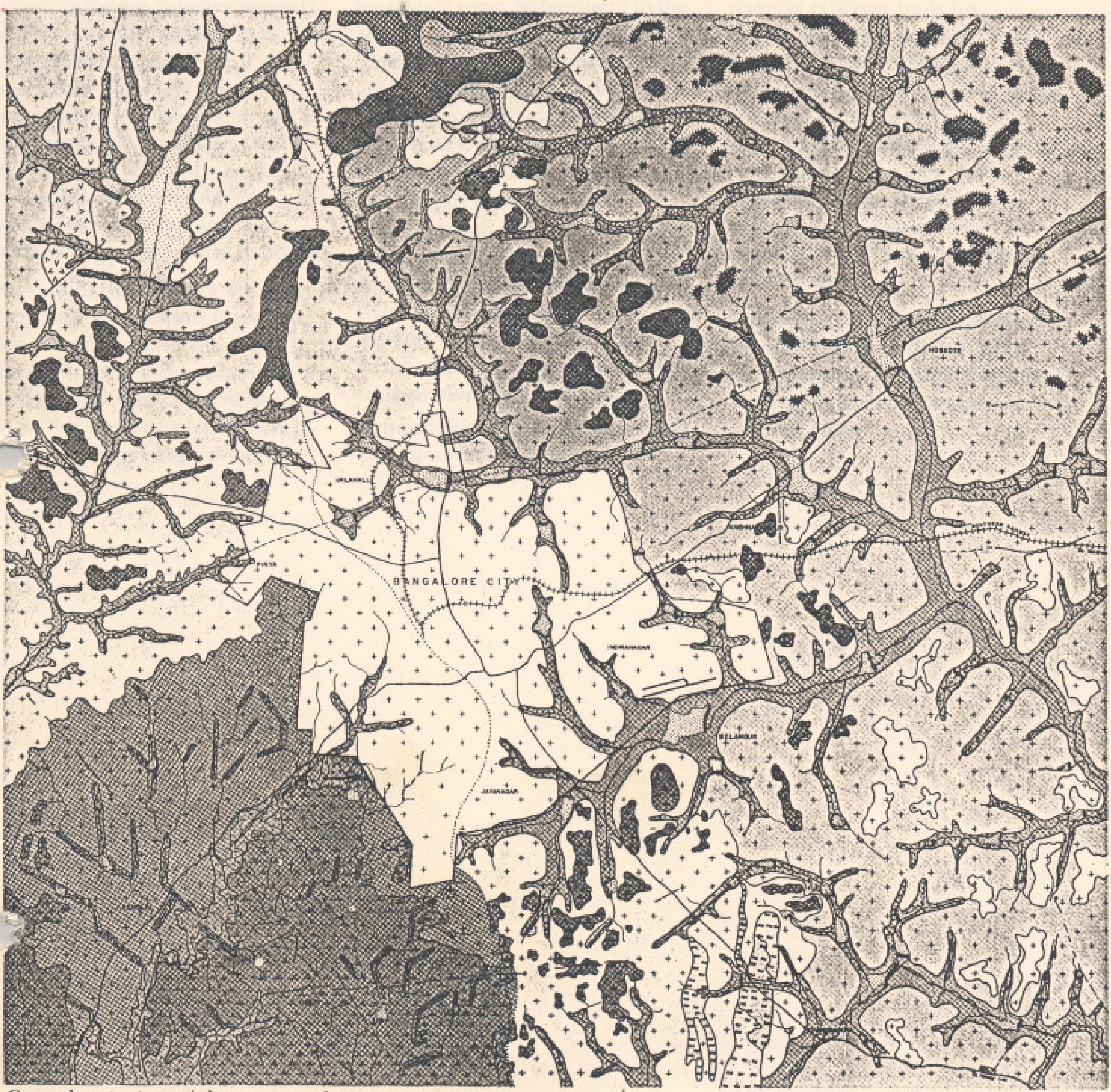
Satellite Data for Ground Water Mapping

The Department of Space, in association with the concerned State Government agencies like state remote sensing application centres, has completed the mammoth task of preparing hydrogeomorphological mapping for the entire country using satellite imageries. The project was initiated in 1987 under the National Drinking Water Mission directed towards providing 40 litres per capita per day (LPCPD) of potable water, with an additional 30 LPCPD for cattle in desert areas, to all the villages in India. The Department of Space took up the responsibility of preparing ground water potential zone maps (Hydro-geomorphological maps) showing potential zones/locales where there is a high probability of finding ground water. Maps for 447 districts covering the entire country on a 1:250,000 scale are now available to the users in the country, viz. State Public Health Engineering Departments/State Ground Water Departments and Central Ground Water Board/ Regional Directorates. These maps, based on satellite data, serve as the starting point for identifying underground aquifer for providing basic drinking water to rural population.

The recurrent failures of monsoon and the depletion of ground water table create severe drought conditions in many parts of the country. In unconsolidated formations the occurrence and movement of ground water is mostly confined to the zones of



METHODOLOGY FOR GROUND WATER POTENTIAL ZONE MAPPING



Ground water potential zone map of Bangalore City and surroundings.

- Very Good
- Good potential, depending upon the thickness.
- Nil.
- Poor to Moderate, depending upon the depth of weathering & intensity of fracturing.
- Moderate to good, depnding upon the depth of weathering and intensity of fracturing.
- Poor to moderate.
- Nil, Poor to moderate Potential along narrow valleys, faults & fractures.
- Nil (Except along Fractures/Faults).
- Poor (Moderate potential along the narrow valleys, Fractures/Faults).
- Poor to moderate potential, depending upon the depth of weathering
- Moderate to good, depending upon the depth of weathering.
- Poor potential within the dyke rock But good potential on the upstream side of the dyke.
- Good to Very good depending upon the intensity of Fracturing/Faulting.
- Good.

materials having primary porosity. In the semi-consolidated and consolidated formations, it is largely controlled by the prevalance and orientation of open space viz. fractures, joints, fault plain, cracks and the thickness and the extent of weathered residuum and also favourable topographical features.

Since the ground water is a sub-surface phenomenon, there is a need to understand the sub-surface hydrological conditions through the surface expressions. Aerial photographs have been in use for hydrogeological mapping for several years. Subsequent to the advent of space-based remote sensing, however, the satellite data are being widely employed for deriving ground water exploration parameters, especially through visual interpretation techniques.

In general, satellite image interpretation in conjunction with aerial photographs and conventional methods of surveying helps in selecting areas with ground water potential. This is being now carried out by many organisations in the country.

Ground water potential zone maps prepared from satellite images serve as efficient tools for narrowing down potential zones for further hydrogeological and geophysical surveys, leading to the selection of suitable sites for borewells/dug wells. User agencies have reported success rates between 88 and 95 percent for striking water against 45 to 55 percent using only conventional techniques.

It is for the first time that the entire country has been mapped at district level on 1:250,000 scale for such an important resource as the ground water. □

Precision Radars

For Launch Vehicles

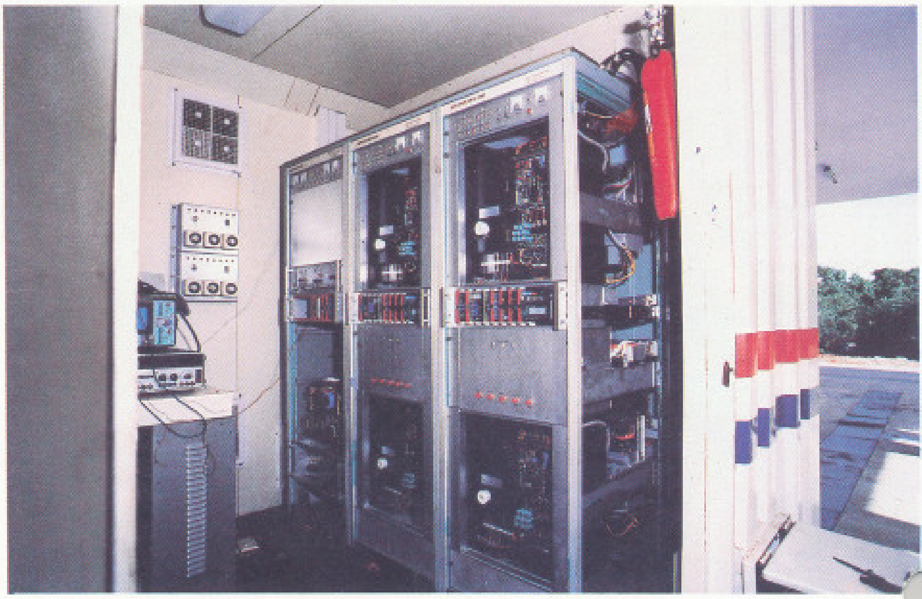
The Precision Coherent Monopulse C-band Radar (PCMC Radar) is a high precision tracking instrument to be used as a part of ground system for PSLV launch. The primary purpose of this Radar is to ensure range safety and to aid in the performance analysis of the launch vehicle. PCMC Radar has the capability to acquire and track PSLV upto a range of 3,200 km and provide time tagged position data, namely, range, angle (azimuth and elevation) and range rate, with the specified accuracies.

The PCMC Radar has been indigenously designed and developed jointly by ISRO and Bharat Electronics Ltd., (BEL), Bangalore. ISRO had earlier developed and installed conical scan type of Radars in S-band and C-band, both transportable and non-transportable versions. These Radars have been used for SLV-3 and ASLV missions. PCMC Radar has better capabilities in terms of angular accuracy and incorporates state-of-the-art features such as high power coherent transmitter, Doppler processor, automatic TV tracking, star calibration, built-in test equipment and synthetic PPI (Plan Position Indication) display. Most of the electronic systems, such as transmitter, receiver, range and Doppler trackers, data processing computer, console and displays have been developed by BEL. The antenna system including pedestal, reflector, servo system, optical calibration subsystem, etc., have been developed by ISRO, with the assistance of Indian industries/institutions.

Two PCMC Radars are planned to be installed at SHAR and one at the PSLV down range station.

The functional specifications of the Radars meet the exacting requirements of the PSLV mission including the following.

- Accurate calculation of instantaneous impact point and ground-trace for range safety.
- Provision of continuous tracking support from lift-off to spacecraft separation for the evaluation of vehicle performance.
- Provision of continuous trajectory data to real time computers for supplying pointing information to telemetry/slave antennae.



Servo power amplifier unit.

Data processing system.

Control console.

SPECIFICATIONS

Type	Transportable, high precision, monopulse tracking radar
Antenna	Cassegrain system with elevation over azimuth mount
Transmitter	Coherent, Codeable
Receive modes	Skin, transponder (coherent, non-coherent and mixed modes)
Tracking modes	RF monopulse and optical
Modes of operation	Automatic, manual, aided, designate, coasting, standby, test/simulate, on-axis, scan/surveillance
Frequency of operation	5.4 to 5.9 GHz
Transmitter peak power (minimum)	1 MW
Pulse repetition freq. (selectable)	585.5 PPS, (Nominal) 292.75, 146.375 PPS
Pulse width (selectable)	1, 0.5 & 0.25 micro sec.
Pulse coding	2 pulse or 5 pulse
Antenna gain	43 dB (Min)
Reflector diameter	4m
Receiver system sensitivity	-137 dBW

TRACKING

Range

Unambiguous coverage	4096 km
Precision	1 m (approx)
Range Rate	15 km/sec.
Range acceleration	2 km/sec/sec.
Accuracy	10m at S/N of -16 dB

Angle

Azimuth coverage	Continuous
Elevation coverage	-5 deg to +185 deg.
Rate (Az & El)	500 mil/sec
Acceleration (Az & El)	500 mil/sec/sec.
Accuracy	0.1 mil at S/N of -16 dB

Doppler

Frequency range	+/- 600 kHz
Doppler rate	+/- 80 kHz/sec
Doppler resolution	1 Hz
Doppler accuracy	Better than 1m/sec at S/N of -16 dB

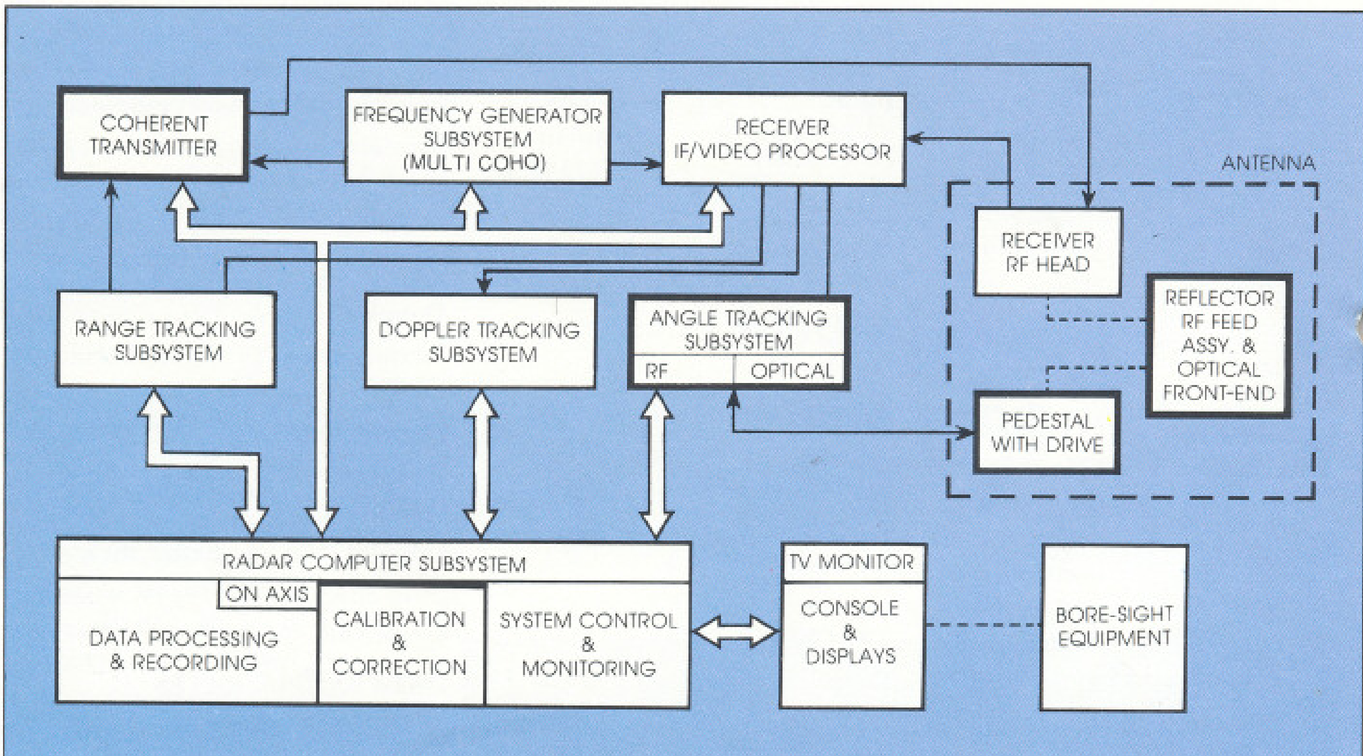
DATA SAMPLE RATES

Minimum	1 sample/10 sec.
Maximum	40 samples/sec.
Recording rate	100 samples/sec.
Radar displays	A-scope, F-scope, PPI, console monitor, TV monitor, graphics terminal and self scan

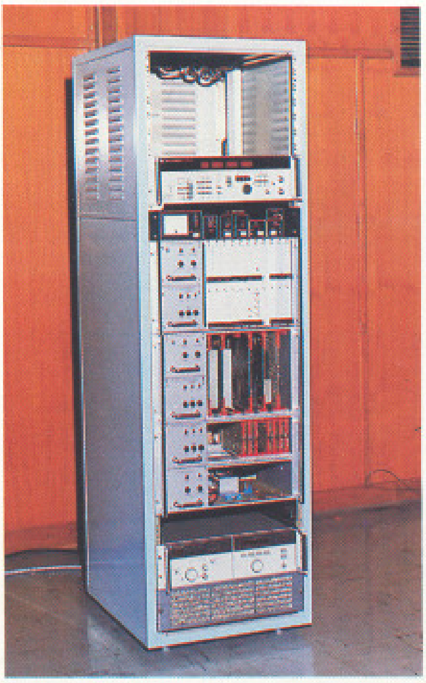
- Preliminary orbit determination to enable acquisition of the spacecraft in the subsequent orbit.

PCMC Radar development was started in 1983 and all subsystems for the first Radar have since been realised. Installation of this Radar is in progress at SHAR. Major subsystems for the second Radar have also been realised and its installation has commenced.

The PCMC Radar is capable of tracking a transponder of 400W peak power upto a range of about 1,600 km with 0.1 mil angular accuracy and 3,200 km with 0.2 mil angular accuracy. In the skin mode it can track one square metre cross section target upto 200 km range. □



PCMC RADAR BLOCK DIAGRAM



Receiver unit.

PCMC Radar-1 at SHAR Centre.

National Space Science Symposium – 1990

Inaugural address by Prof. U.R. Rao, Chairman, ISRO.

The Orange City of Nagpur was the venue of the National Space Science Symposium held during March 5-9, 1990. The symposium was dedicated to the memory of late Prof. S.K. Mitra, on the occasion of his birth centenary. Prof. Mitra's contributions to Upper Atmospheric Physics and Radio Science are known all over the world.

The National Space Science Symposium is held once in two years, each time in a different city. The symposium at Nagpur was sponsored and organised by the Indian Space Research Organisation and Nagpur University. It was co-sponsored by the Department of Science and Technology, Council of Scientific and Industrial Research, Indian National Science Academy, University Grants Commission and the Government of Maharashtra. This symposium provides a unique forum for scientists in India working in all disciplines of space science to come together and discuss progress of their research work, present new scientific results and formulate further research plans.

The topics covered at Nagpur included astronomy, atmospheric sciences, space meteorology, study of global change, science of remote sensing, origin of life and microgravity. There were totally 300 participants from more than 50 research laboratories and universities in the country.

In his inaugural and keynote address "The Indian Space Scenario in the Early Twenty first Century", Prof. U.R. Rao, Chairman, ISRO, highlighted the progress the country has made so far in harnessing the potential of space technology for direct applications. He elaborated through specific examples the operational use of space-based systems for national telecommunications, TV broadcast, meteorology and disaster warning, resources survey and management, etc. The future Space Programme and its relevance to the country in the coming decades were also dealt with by Prof. Rao.

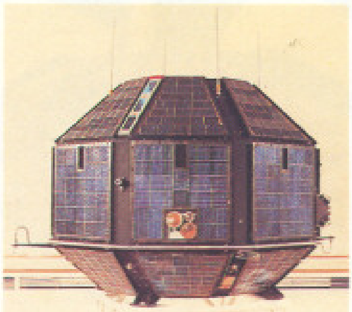
Dr A.P.Mitra, Director General, Council of Scientific and Industrial Research, delivered the S.K.Mitra Memorial Lecture titled "Aeronomy from the days of S.K. Mitra to now and beyond". Apart from giving the historical account of the growth of research in India in this field, he also indicated the directions where future thrust is needed.

About 250 contributed research papers and a large number of invited talks by experts in the field were presented. All contributed papers were presented on posters, which is a standard practice of this symposium. A special feature of the symposium was a number of theme sessions of topical interest arranged with the objective of focussing attention on certain upcoming research opportunities and to work out an approach for involving all the interested research groups. The research topics so addressed included Indian participation in the international Jupiter watch, effective utilisation of the Mesosphere, Stratosphere and Troposphere Radar facility at Tirupati, coordination of further research on equatorial electrojet, application of IRS data for scientific research, study of global change, review of opportunities for microgravity research and setting up of some ground-based research infrastructure related to this, promotion of research on origin of life and geochronological requirements for further work in this area, etc.

An exhibition on the Indian Space Programme was an additional attraction of the Nagpur Symposium. □

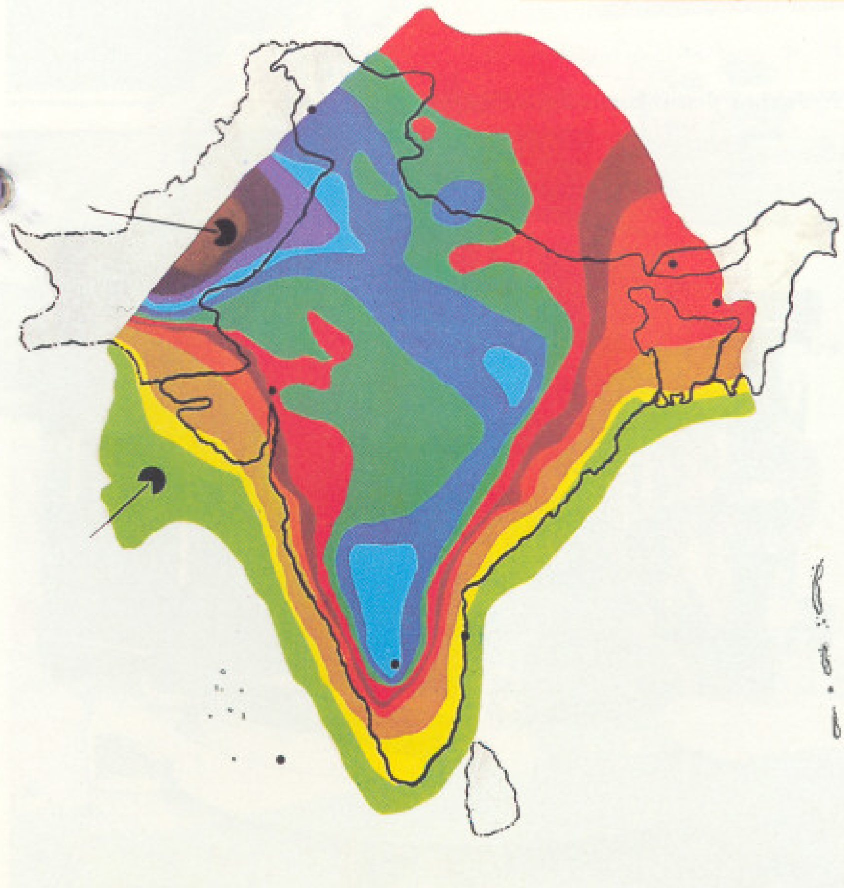
An award winning Poster.

An Eventful Decade For Indian Space Programme



The 80's decade had been a momentus one for the Indian Space Programme. The most significant achievement of the 80's was India's entry into the operational phase, both in the fields of communications and remote sensing. While the commissioning of INSAT system signalled the beginning of operational space services in telecommunications, TV and meteorology, that of the indigenous IRS-1A symbolised operationalisation of remote sensing services in the country. IRS-1A has now become the mainstay of the National Natural Resources Management System (NNRMS).

INSAT-1 series and the IRS-1A were preceded in the same decade by indigenous efforts in the form of APPLE (Ariane Passenger Payload Experiment) and Bhaskara-II (Bhaskara-I was launched in 1979). APPLE was India's first 3-axis stabilised experimental communication satellite through which ISRO gained valuable hands-on experience on time, frequency and code division multiplexing (TDMA, FDMA and CDMA), computer interconnect, random access and packet switching, radio networking and so on.



Bhaskara and SAMIR imagery

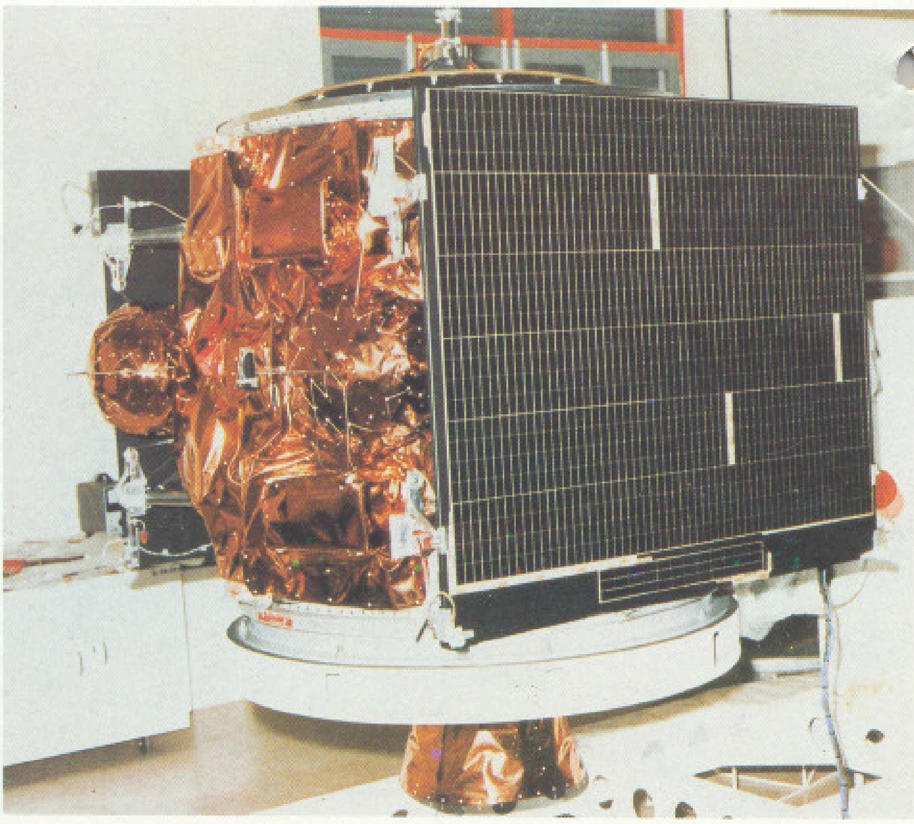
Similarly, Bhaskara satellites helped ISRO know the ropes, so to say, in the design and operation of remote sensing spacecraft. The cameras on board Bhaskara, operating in the visible and near-infrared, provided imageries with 1 km resolution. These imageries could be used to build a mosaic of the country, making it possible to delineate features of importance in agriculture, forestry and water bodies.

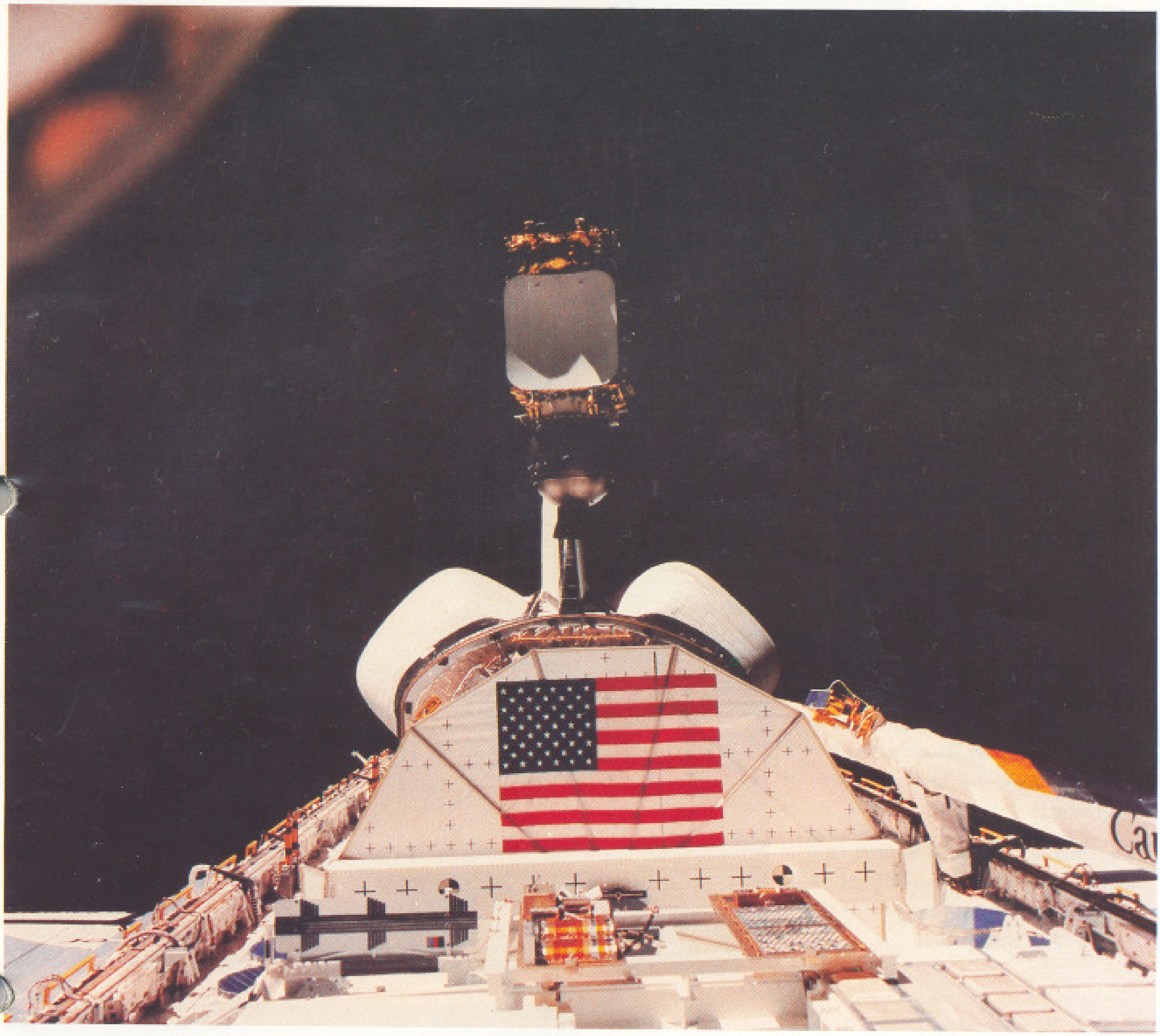
The 80's also witnessed the historical success of SLV-3, the first satellite launch vehicle developed indigenously. The fact, that ISRO could launch SLV-3 thrice successfully, demonstrated the Indian capability in launch vehicle technology. This paved the way for two more launch vehicle projects, ASLV and PSLV. Though the first two launches of ASLV failed to complete their mission they helped validate some of the critical technologies that had been incorporated into the design of ASLV eg., strap-on technology, inertial navigation and closed-loop guidance, vertical integration, S-band telemetry and bulbous metallic heatshield.

The decade also saw good progress in two of the major projects of ISRO, PSLV and the INSAT-II Test Spacecraft. All the propulsion modules of PSLV have been tested successfully on ground and it should be possible for ISRO to launch PSLV within a year or two. The development of INSAT-II Test Spacecraft, the precursor to the operational second generation INSAT-II Spacecraft which will replace the foreign procured INSAT-I spacecraft also made substantial progress with the realisation of all subsystems including the communication payload and VHRR for Electrical Thermal and Structural Model. The decade witnessed a substantial growth in the ISRO industry co-operation as demonstrated by the

Sounding Rockets were used for major science projects – MONEX and IMAP.

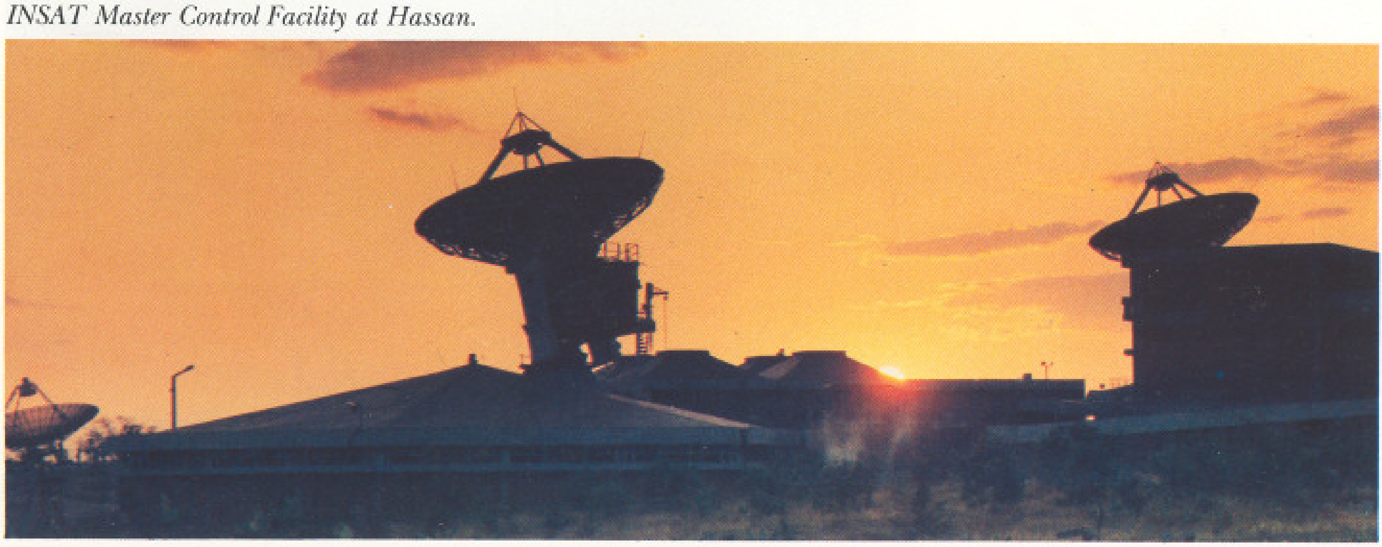
APPLE, India's first communication satellite.





INSAT-1B being deployed from Space Shuttle.

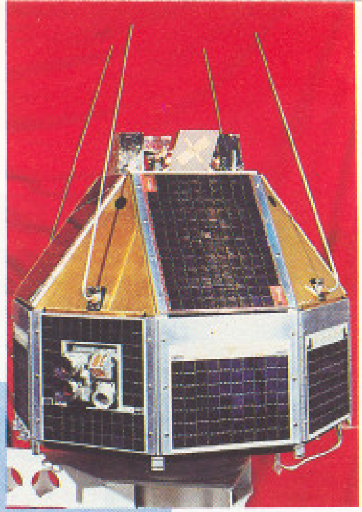
INSAT Master Control Facility at Hassan.

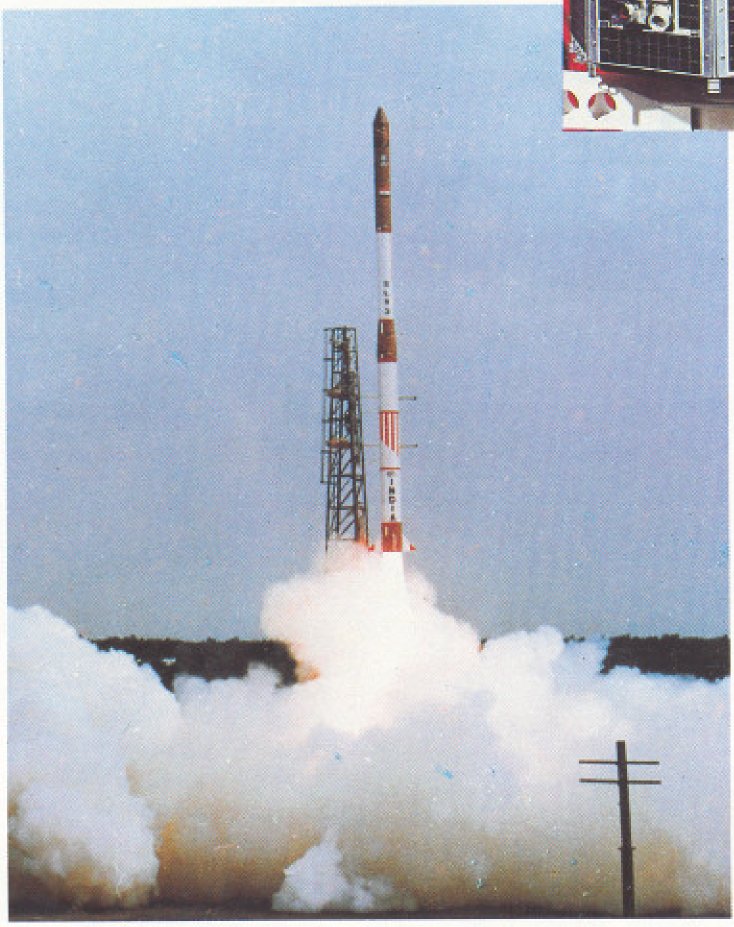


participation of Indian industry in ISRO's projects, namely, PSLV, IRS and INSAT and establishment of infrastructure such as Mobile Service Structure, Large Space Simulation Chamber and MCF augmentation. As many as 162 technologies had been transferred to industries till the end of the decade. Major science campaigns like the Monsoon Experiment (MONEX) and Indian Middle Atmospheric Programme (IMAP) were successfully completed during the decade.

Yes, the Indian Space Programme had had its share of disappointments (INSAT-1A, I-C, ASLV) and success (INSAT-1B, IRS-1A, SLV-3) during the decade, but it was a decade of excitement, growth and transition - transition from experimental to operational phase. It was a decade whose memories will be cherished for a long long time by those actively associated with the Indian Space Programme.

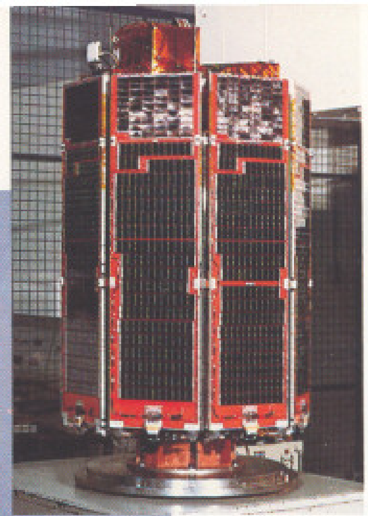
In a, perhaps, justifiably nostalgic move, Space India reproduces in these pages a picture parade of the decade that was 80's. □



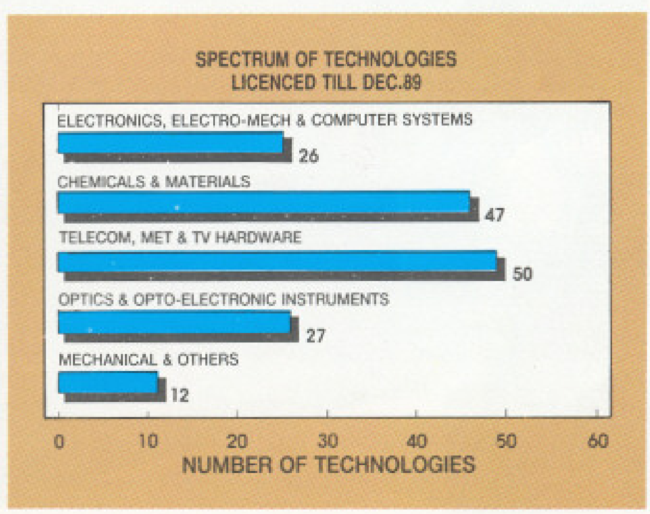


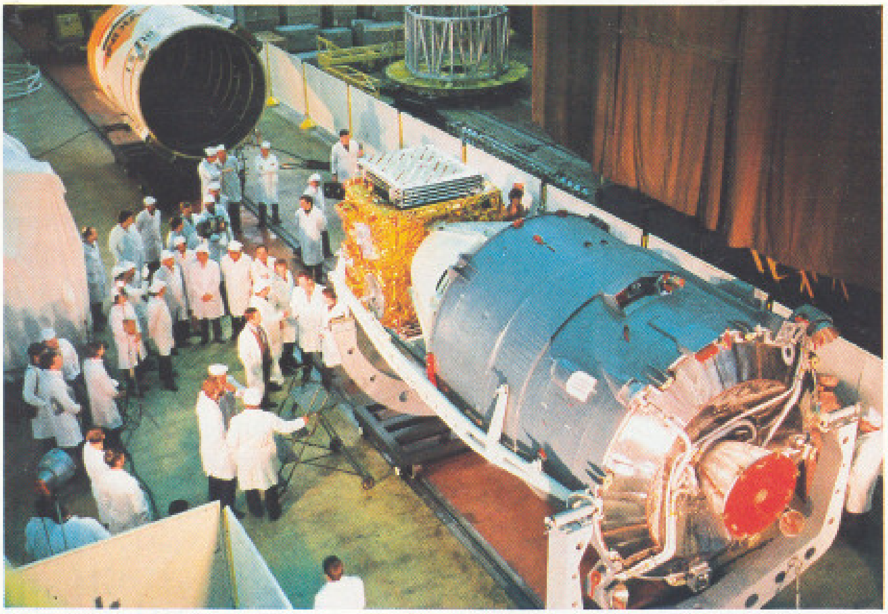
SLV-3, India's first Satellite Launch vehicle and Rohini.

Prof. U.R. Rao, Chairman, ISRO (right) with Rakesh Sharma, the first Indian in Space and Ravish Malhotra.



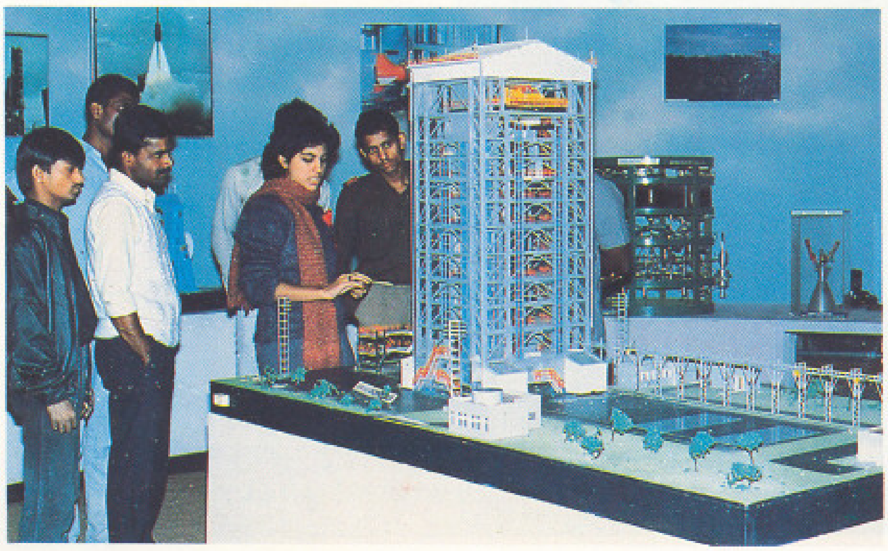
ASLV and SROSS.





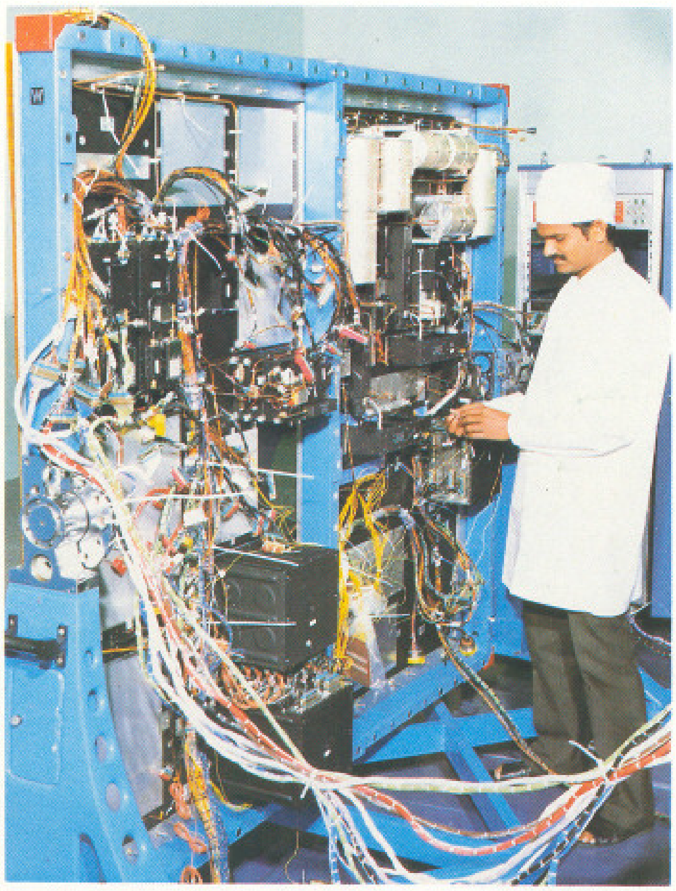
IRS-1A being mated with USSR 'VOSTOK' rocket.

ISTRAC station at Lucknow.



"Space and Man's Future" exhibition held at New Delhi.

Model of PSLV in the New DOS/ISRO Headquarters building, Bangalore.



Communication payload for INSAT-II TS.

A view of the PCMC Radar at SHAR Centre.