OCT '92 - MAR '93

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

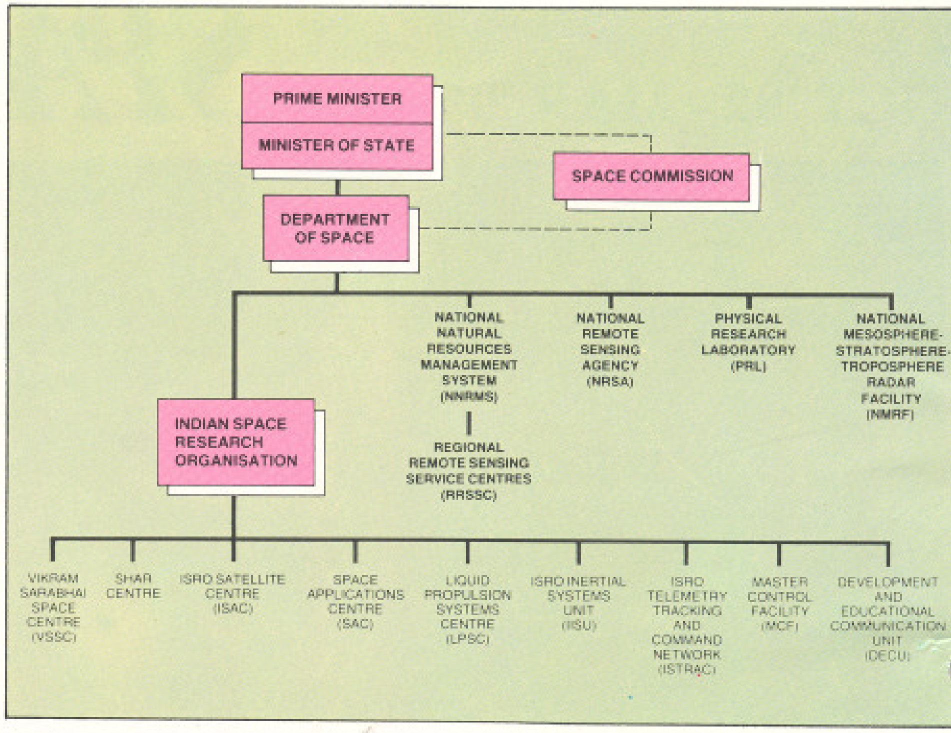
The Indian Space Programme

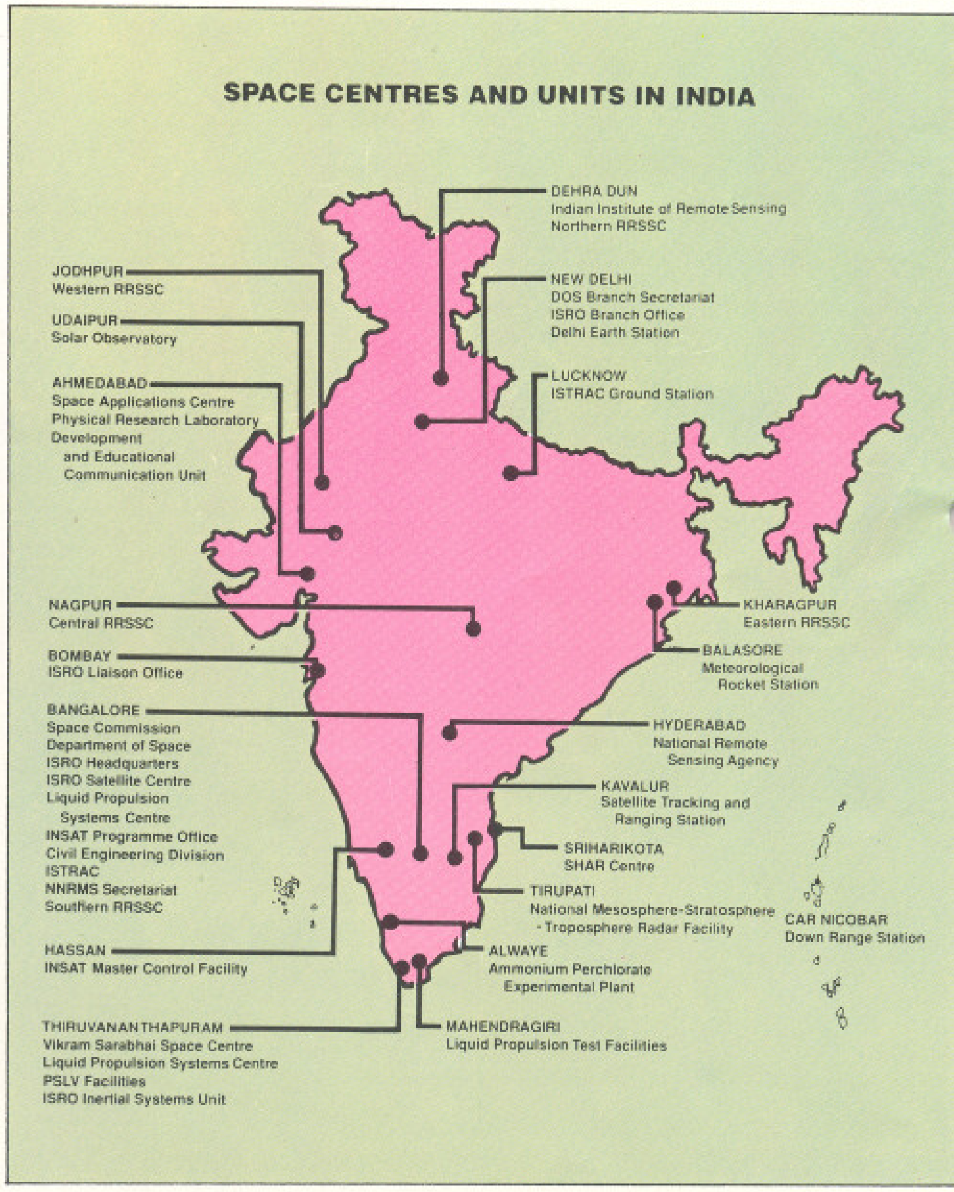
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science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

Assembly mock-up model of PSLV

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Contents

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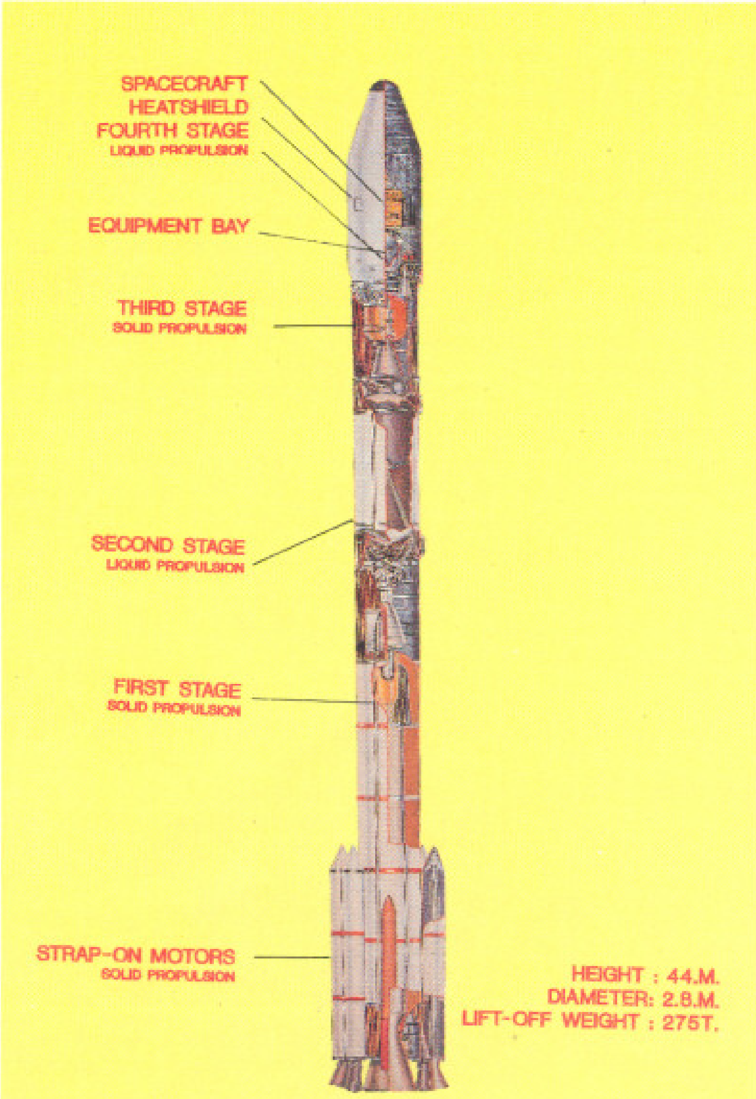
PSLV First Developmental Flight– Preparations in Full Swing



The main objective of the Indian Space Programme is to provide uninterrupted services to the nation in two of the most vital areas crucial for development: remote sensing and communications. Currently, these operational services are being provided by the indigenously built satellites, IRS-1A and 1B and INSAT-2A launched from abroad. But the bottom line in ISRO's programme to harness space technology for national development is self-reliance which evidently applies both to spacecraft and launch vehicle technology.

The Polar Satellite Launch Vehicle, PSLV represents ISRO's first attempt in rocketry to acquire indigenous capability in launching IRS class of satellites weighing 1000 kg. Configured as a four stage vehicle with alternate solid and liquid propulsion modules, PSLV, is now getting ready for the maiden flight this year. With the Vikram Sarabhai Space Centre in Thiruvananthapuram acting as the lead-centre for rocketry in ISRO, major responsibilities for design and development of PSLV are shared by the Liquid Propulsion Systems Centre, also headquartered in Thiruvananthapuram and the SHAR Centre in Sriharikota. ISRO Innertial Systems Unit, Thiruvananthapuram, has developed the inertial navigation system.

The basic mission of the first developmental flight of the vehicle, PSLV-D1, is to inject the engineering model of the Indian Remote Sensing Satellite (IRS-1E) into sunsynchronous polar orbit. IRS-1E will carry a Monocular Electro Optical Stereo Scanner developed by DLR, Germany, and a LISS-1 camera, similar to that on board IRS-1A.

Rated as the third largest solid booster in the world, the first stage of PSLV carries 128 tonne of propellant and measures 2.8 m in diameter. The motor case is made of maraging steel which is also indigenously produced specifically for the Indian Space Programme. The booster, which burns for about 100 sec, develops a maximum thrust of 4,500 kN necessary to lift the vehicle with specified acceleration. The first stage thrust is augmented by six strap-on motors each of which produces a thrust of about 660 kN. These solid propellant strap-on motors, two of which are ignited on the ground and the remaining about 30 sec. after lift-off, are derived from the first stage of SLV- 3.

The five-segment first stage solid booster

The solid booster uses indigenously produced propellant which is a combination of the Hydroxyl Terminated Poly Butadiene (HTPB) fuel and Ammonium Perchlorate oxidiser.

The second stage, which uses the indigenously manufactured VIKAS liquid engine, has a propellant loading of over 37 tonne and generates a maximum thrust of about 725 kN. It uses UDMH (Unsymmetrical Dimethyl Hydrazine) as the fuel and Nitrogen tetroxide (N_2O_4) as the oxidiser.

The third stage which again uses a solid motor capable of producing a maximum thrust of 340 kN has a propellant loading of 7.2 tonne; the motor case is made of polyaramide (Kevlar) fibre. Like the first stage, this too is powered by the HTPB based propellant.

The fourth and the terminal stage of PSLV, which finally injects the IRS-1E satellite into a sunsynchronous polar orbit with a velocity of over 7.4 km/sec, has a twin liquid engine configuration.

Static testing of PSLV first stage motor

Each of these engines, with a propellant loading of 2 tonne (Monomethyl hydrazine + N_2O_4) is capable of generating a maximum thrust of 7.4 kN.

A metallic bulbous heatshield of 3.2 m diameter and of isogrid construction, offers to the atmosphere an aerodynamically compatible shape besides protecting the spacecraft from the hostile environment that is inevitably encountered during the atmospheric regime of the flight. The heatshield is jettisoned around an altitude of 100 km.

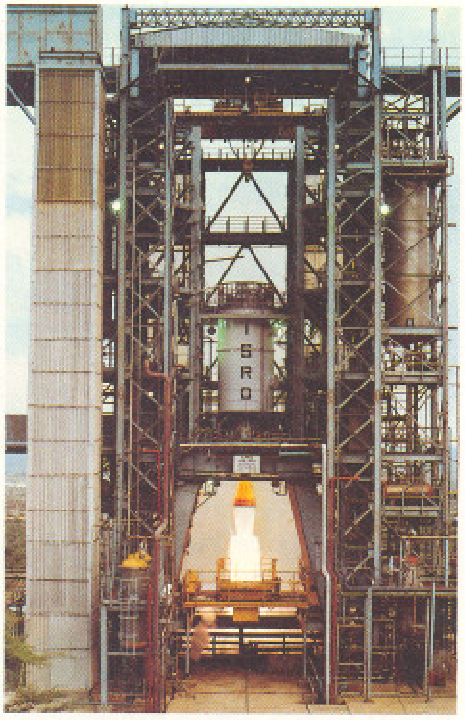
Each of the stages is provided with autonomous control systems:

First Stage	: Secondary Injection Thrust Vector Control for pitch and yaw
	: Reaction Control System for roll
Second Stage	: Engine Gimbal Control System
Third Stage	: Flex Nozzle Control System
Fourth Stage	: Engine Gimbal Control System

The inertial navigation system used for PSLV is the strap-down version with guidance system resident in the equipment bay and guides the vehicle till the injection of spacecraft into the orbit. The closed-loop guidance scheme assures the required accuracy of injection.

The main on-board instrumentation packages used for telemetry, tracking and command are :

- PCM/S-band telemetry systems
- S-band Range and Range rate transponders



Liquid propulsion second stage undergoing ground test

- C-band transponders

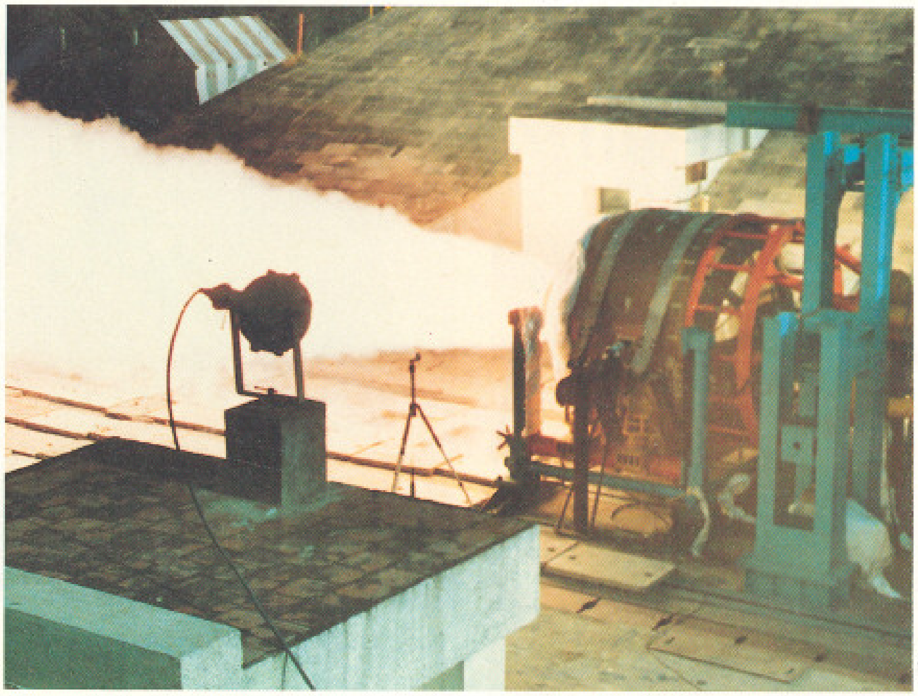
besides a host of power and signal conditioning packages.

There is a large number of stage auxiliary systems incorporated with the vehicle which perform functions like stage separation, heatshield separation and jettisoning, etc.

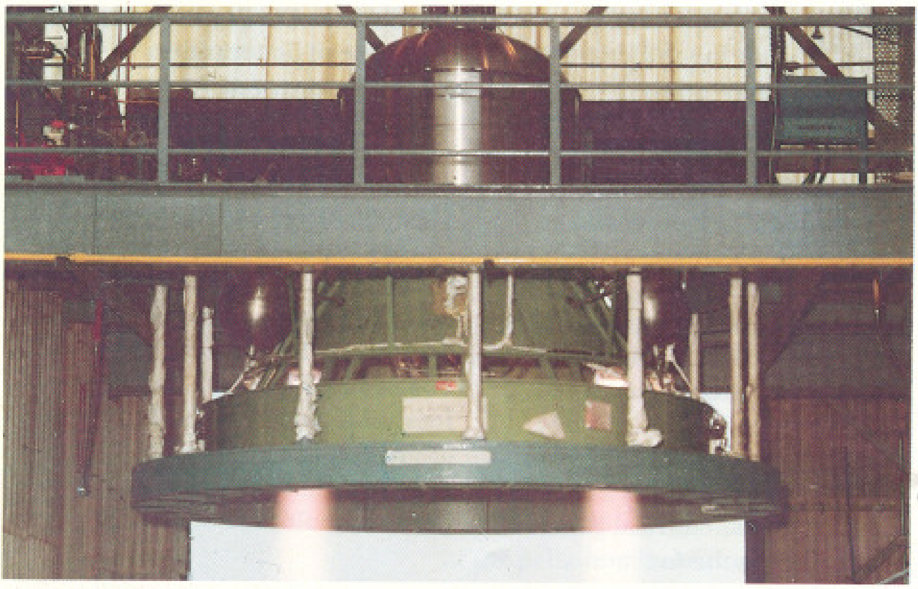
New Infrastructure

Some of the technologies used in PSLV have been derived from those already demonstrated earlier through the SLV-3 and the ASLV (Augmented Satellite Launch Vehicle) programmes. Examples are: solid-propellant and propulsion systems, strap-on technology, bulbous heatshield, real-time decision systems, closed-loop guidance, vertical assembly and integration procedures and S-band electronic systems. Yet, PSLV employs a host of new ones. For the first time, ISRO is deploying liquid engines for primary propulsion in a launch vehicle. Other important new technologies are : 2.8 m diameter large size solid booster, flex nozzle and engine gimbal control systems, and strapdown inertial navigation systems.

To design, develop and demonstrate these new technologies, ISRO had to augment the infrastructure in some areas and create new ones in the others both within and outside ISRO. For example, the Liquid Propulsion Systems Centre (LPSC) which is charged with the responsibility of designing and developing all liquid propulsion modules for both launch vehicles and spacecraft, has established Liquid Stage Test Facilities and Control Component Development Facilities. The SHAR Centre which provides, among others, all launch facilities, has established the large solid booster preparation and test facilities, the Mobile Service Tower and a separate launch complex for PSLV. Similarly, the Vikram Sarabhai Space Centre (VSSC) has created a new complex at a place called Valiamala (near Thiruvananthapuram) where a large number of new facilities is established for integration and checkout, large scale structural testing (like Ground Resonance Testing), testing separation and jettisoning systems and so on.



Third stage solid propulsion motor static test



Fourth stage Liquid propulsion stage under test

Participation by Industry and Academic Institutions

A stated objective of ISRO is to maximise utilisation of expertise and facilities already available with the academic institutions and industry. The Indian Institute of Science, Bangalore, and the Indian Institutes of Technology in various parts of the country are the prime examples of academic institutions which contribute significantly to the projects of

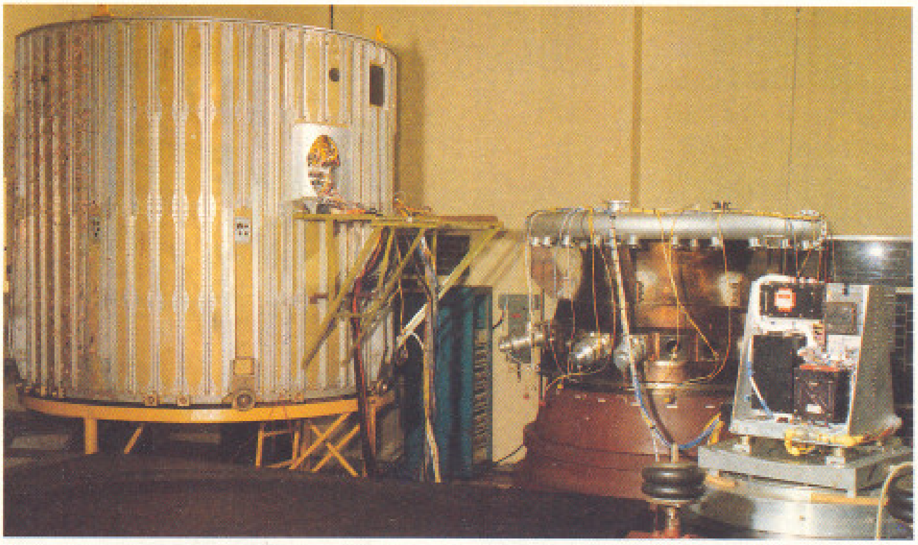
ISRO — and the PSLV project is no exception.

Well over 150 industries, both in the public and private sectors, are responsible for fabrication of a variety of hardware: light alloy structures for interstages, motor cases, electronic packages, heatshield, precision coherent radars, etc. Even in the field of manufacture of chemicals and materials, the industries play a vital role; for example the maraging steel and HTPB resin are also produced by the industries. Prime examples of industries in the public sector which have made major contributions to PSLV are: Hindustan Aeronautics Ltd, Bharat Electronics, Mishra Dhatu Nigam, etc.

Against Heavy Odds: For a developing country like India to venture into space technology is not just a matter of fancy, but a necessity, as the founder of the Indian Space Programme, Dr.Vikram Sarabhai said:

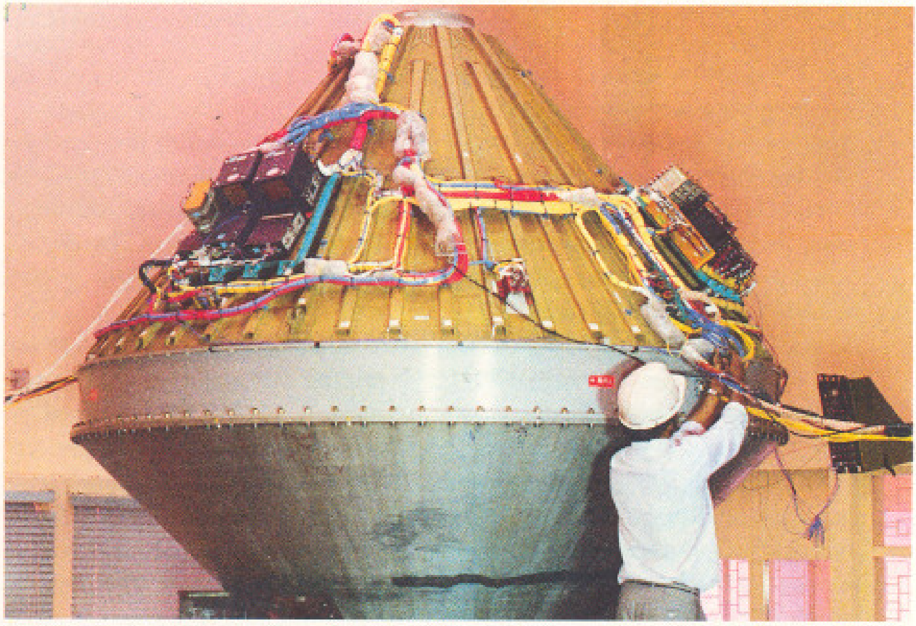
"There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or the planets or the manned space flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the applications of advanced technologies to the real problems of man and the society".

Yes, the very fact that today ISRO emphasises on applications, especially in the two crucial fields of communication and remote sensing, as evidenced by the operational services being provided by the indigenous IRS-1A & 1B and INSAT-2A



Core base-shroud housing

Inter-stage between second and third stages (2/3 L)



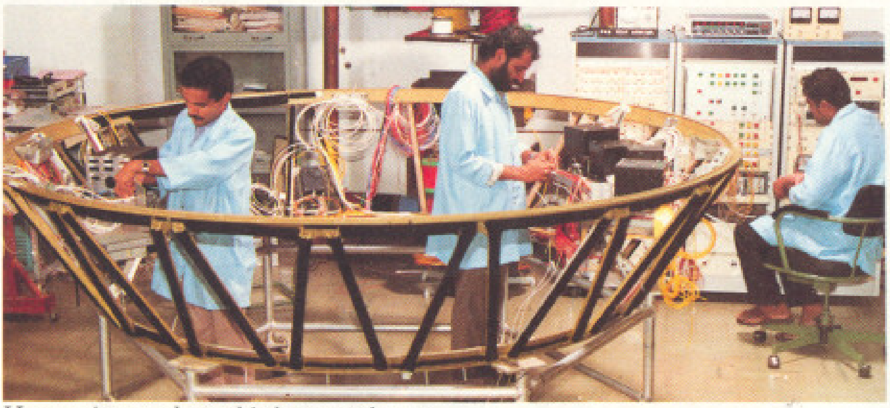
Thrust frame of second stage

satellites, is ample vindication of Dr. Sarabhai's promise to achieve "progress measured in hard economic and social terms".

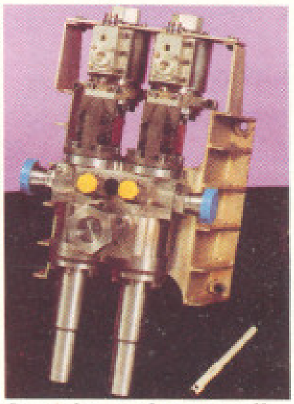
The development of PSLV, which is now set for launch during 1993, was by no means an easy task for India which, besides overcoming socio-economic problems endemic to any developing country, has to cross any number of hurdles in technology development.

There are many examples of technology and material development which were successfully carried out particularly for the PSLV programme. An example is the indigenous production of maraging steel. Another example is indigenous development of the HTPB-based propellant system.

The development of motor case for the third stage, based on polyaramide (Kevlar) fibre, ran into rough weather a number of



Harnessing work on third stage adaptor



Second stage hot gas roll control system

Maraging Steel

Considered strategic, the manufacturing process of maraging steel had been the monopoly of a few industrially advanced countries until recently. Now, scientists at the Indian Space Research Organisation (ISRO) and Mishra Dhatu Nigam (MIDHANI) have indigenised the technology and rocket-booster-motors have been made lighter.

Steel is a common name for a large number of iron-carbon alloys; iron being the major component. In addition to carbon, other alloying elements such as chromium, nickel, cobalt and vanadium are added in chosen proportions to obtain specific properties. Steels in which carbon is the major 'alloying partner' are called carbon steels. Depending upon the carbon content, these steels are classified as low, medium and high carbon steels. In low carbon steels, the percentage (by weight) of carbon is less than 0.25; in medium variety it is between 0.25-0.5 and in high carbon variety it is greater than 0.5.

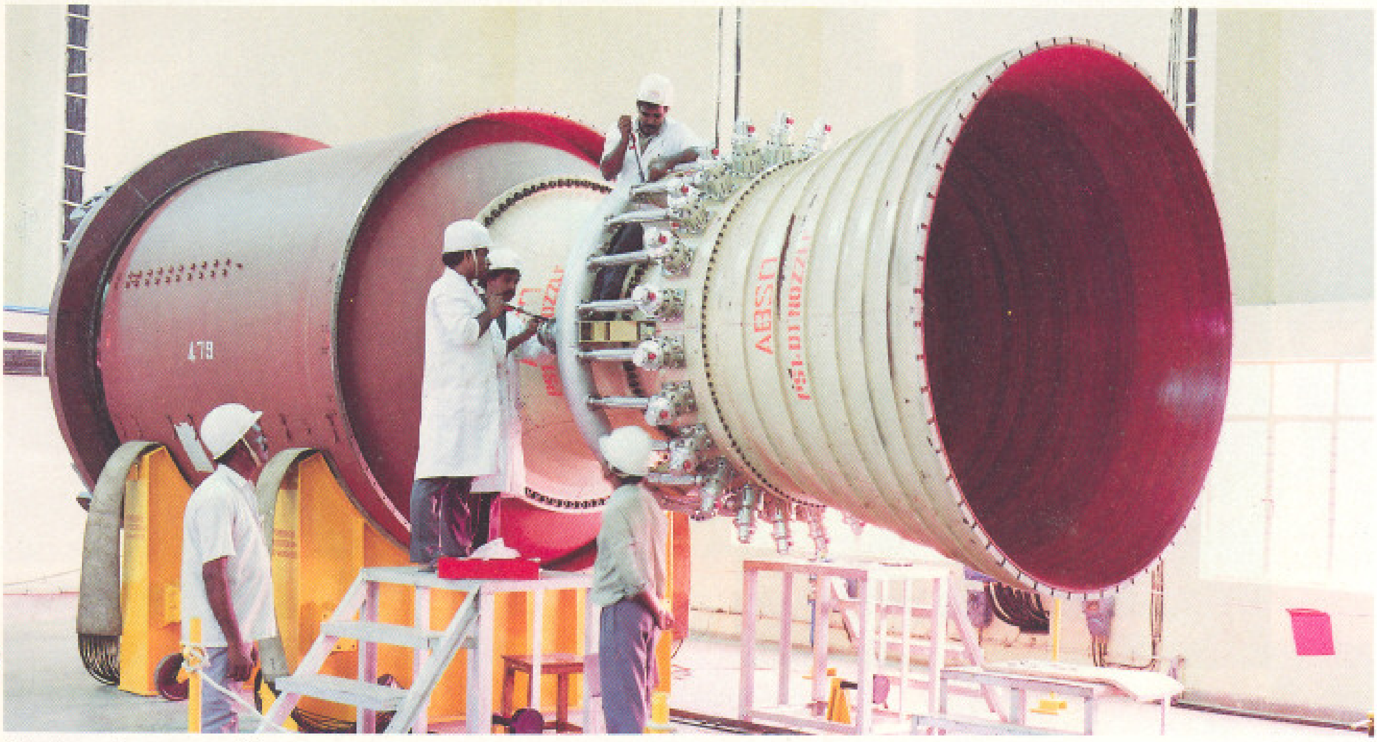
For a material to be called an alloy, the various elements in it must exist in stable arrangements. In carbon steels, there are three thermodynamically stable arrangements of iron and carbon atoms. These phases are called ferrite, austenite and cementite. (Those familiar with crystal structures will notice that ferrite is body-centered cubic, austinite is face-centered cubic and cementite is orthorhombic.) A mixture of ferrite and cementite is called pearlite.

The phases exhibited by steel depend on its temperature and composition. For example, austentie is stable only at temperatures higher than 760 deg. C. Hence, when medium carbon steel is heated to above 910 deg. C it transforms to austenite phase. In this phase, the steel is ductile and heavy sections can be hot-rolled or forged to smaller sizes and complex shapes. When this phase is cooled slowly it transforms to a mixture of ferrite and pearlite. If, however, the cooling is rapid the above transformation is suppressed and a new phase called martensitic is formed. In the martensite phase carbon atoms are trapped between iron atoms and the structure is very strong.

But, unfortunately, the very same structural factors make it brittle. Therefore, martensitic steels are tempered to increase their toughness. Tempering makes the carbon atoms diffuse to form isolated carbide particles within.

So far, we saw steels in which carbon is the major alloying element (Fe-C systems). But there is a new generation of ultra-high strength steel based on iron nickel (Fe-Ni). To this belongs the maraging steel containing negligible amounts of carbon (less than 0.03 per cent). The word Maraging is an acronym derived from two words "martensite" and "aging". Since the word 'steel' is used generally to denote iron-carbon alloys, the very phrase 'maraging steel' is strictly speaking, a misnomer. But the name has stuck.

Besides nickel, the maraging steel contains a host of other alloying



Nozzle-end segment of first stage motor

for PSLV

elements such as cobalt, molybdenum, titanium and aluminium. It is these elements which largely control the properties, for example, the unique combination of high strength and good ductility.

Maraging steels are classified on the basis of yield strength, expressed in kilo pounds per square inch (kpsi). For, example, the maraging steel developed by ISRO is known as 18Ni250 steel. Here 18 refers to the percentage of nickel and 250 to the yield strength in kpsi.

The physical metallurgy of M250 grade maraging steel is governed by the austenite to martensite phase transformation. On heating to above 820 deg.C, it is transformed to austenite phase which on air-cooling (slow cooling) produces a soft Fe-Ni martensite. Aging at 480 deg.C for about three hours provides the desired combination of properties. It is worth noting that in maraging steel the martensite is formed by slow cooling whereas rapid cooling leads to martensite in carbon steel.

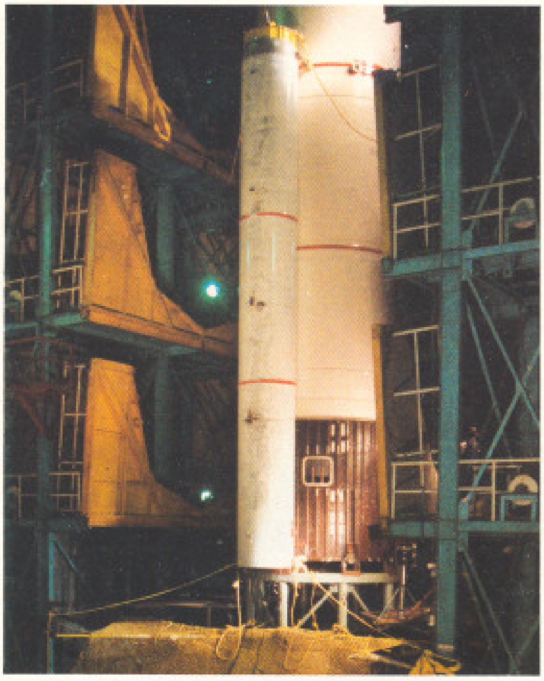
Some of the major differences between the properties of maraging steels and the conventional carbon steels are:

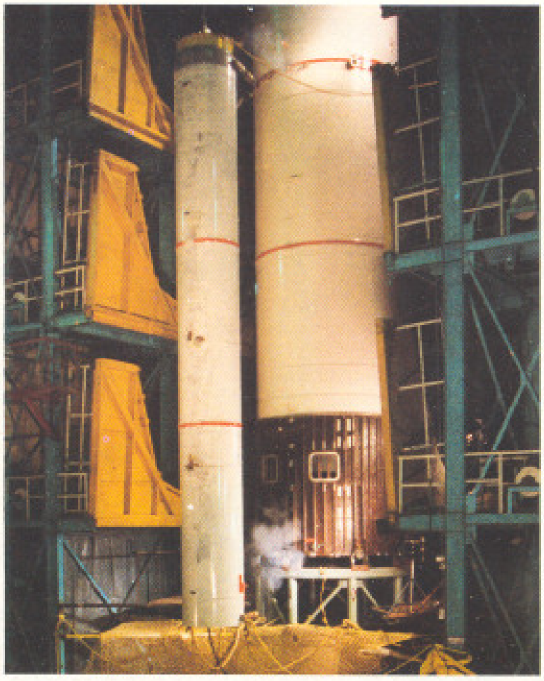
- *The martensite formed from maraging steel is soft and ductile while that formed from carbon steel is hard and brittle.*
- *It is more easily formed and machined (in the martensite condition) than carbon steel of equivalent strength,*
- *It experiences very little dimensional changes, under heat treatment, compared to others.*
- *Unlike carbon steel, very heavy sections of maraging steel can be easily strengthened.*
- *The mechanical properties of maraging steel do not change with work done on them.*

Maraging steel is being indigenously produced for the booster case of PSLV.

Rocket motor cases have to be strong because they have to withstand enormous pressures; this is specially so for the lower booster stages. In its earlier programmes, such as those of SLV-3 and ASLV (Augmented Satellite Launch Vehicle), ISRO had used a special steel 15CDV6. In PSLV the use of maraging steel has halved the weight of booster case.

Nothing in this world comes without a catch, as the saying goes. Weren't there any problem associated with maraging steel? Of course, there were. The first difficulty for ISRO was to indigenise the technology which it did in collaboration with MIDHANI. The second difficulty was that ISRO scientists would be handling the material for the first time, which meant that they had to characterise the indigenous product and verify for the desired properties. All these problems were solved and the first mid-segment of the PSLV booster case was handed over to ISRO by L&T five years ago. By now, ISRO has completely static tested two full scale PSLV boosters.

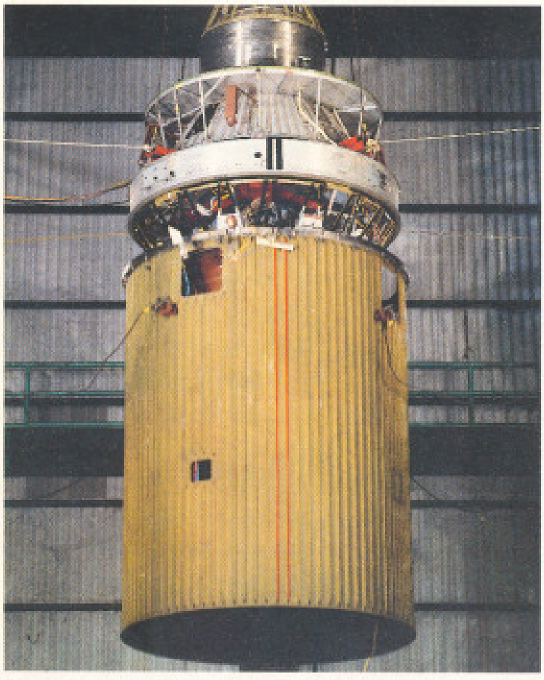


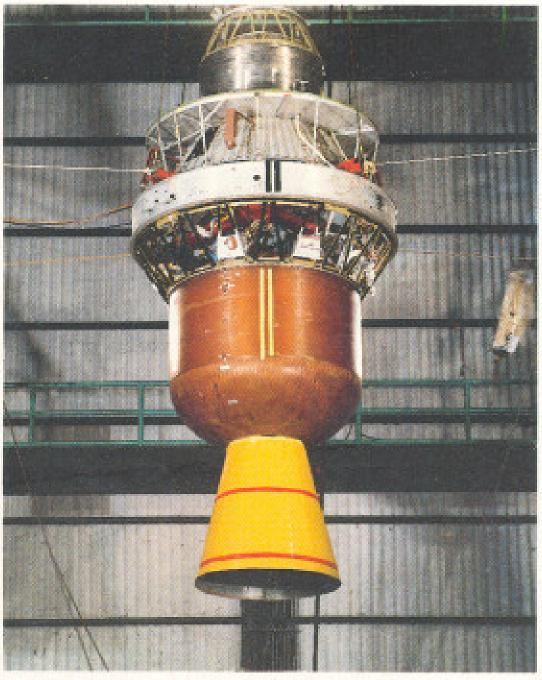


Strap-on motor separation test

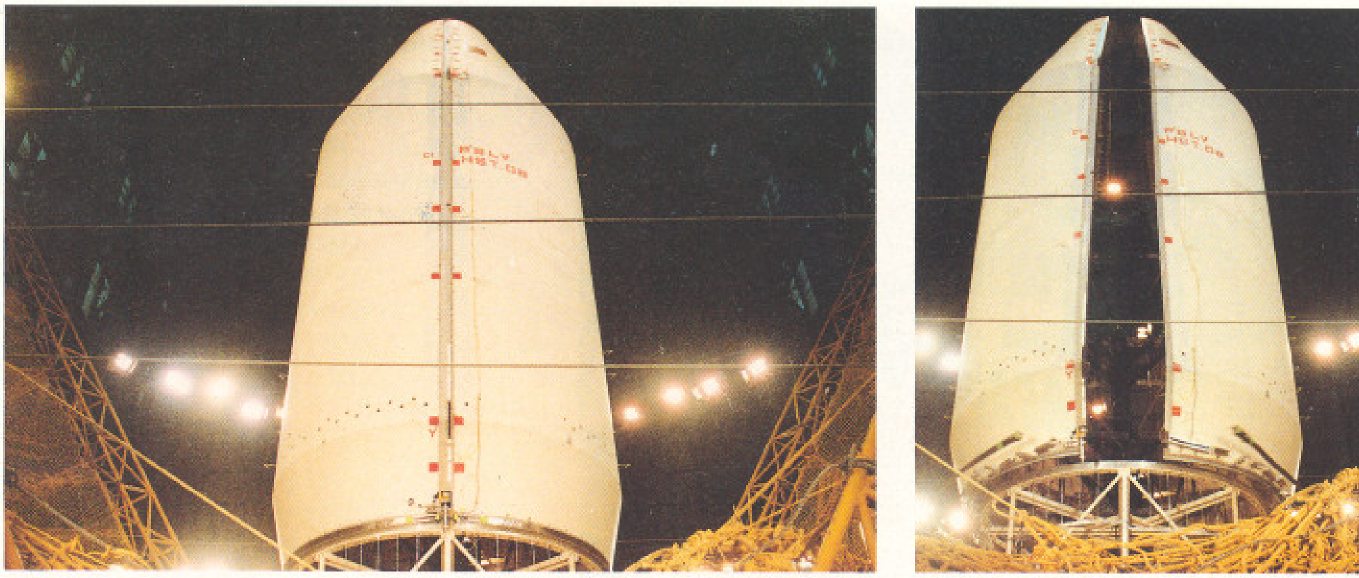
times. At least four prototypes of the motor case had to be made before success was achieved. Some of the other systems and components whose development was pursued successfully against heavy odds are:

- The third stage incorporating submerged nozzle and flex-seal control system.
- Regeneratively cooled liquid engine for the fourth stage.
- Zip cord separation and jettisoning system for the heatshield (in which the whole "explosion" is contained within the rubber bellows, so that any possible contamination of the satellite is avoided)
- Inertial Sensors like dynamically tuned gyros and accelerometers.
- The wheel bogie assembly which moves the 3000 tonne Mobile Service Tower
- PCMC Radar
- A large variety of structures (and their testing)
- Titanium alloy forgings for liquid propellant tankages
- Hardware and software for checkout systems with redundant digital computers and a large number of terminal units and interface modules.

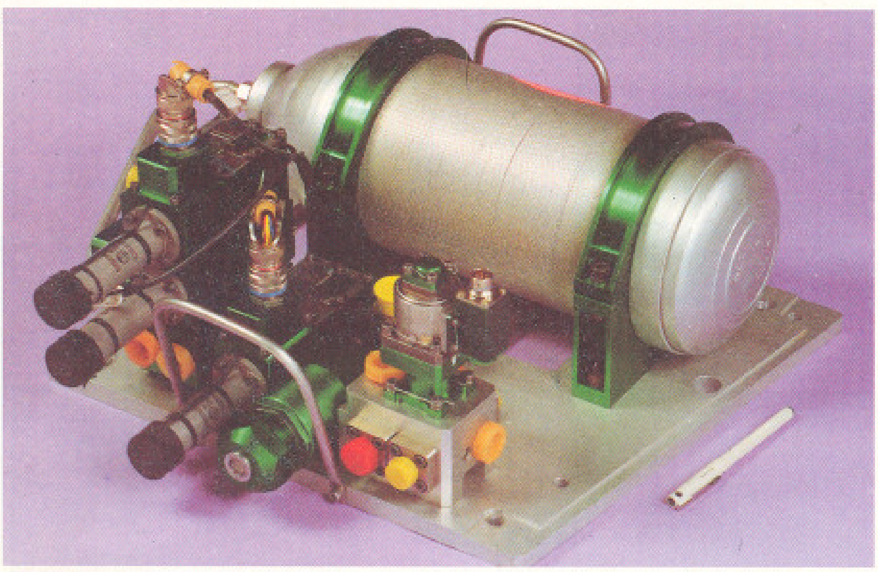




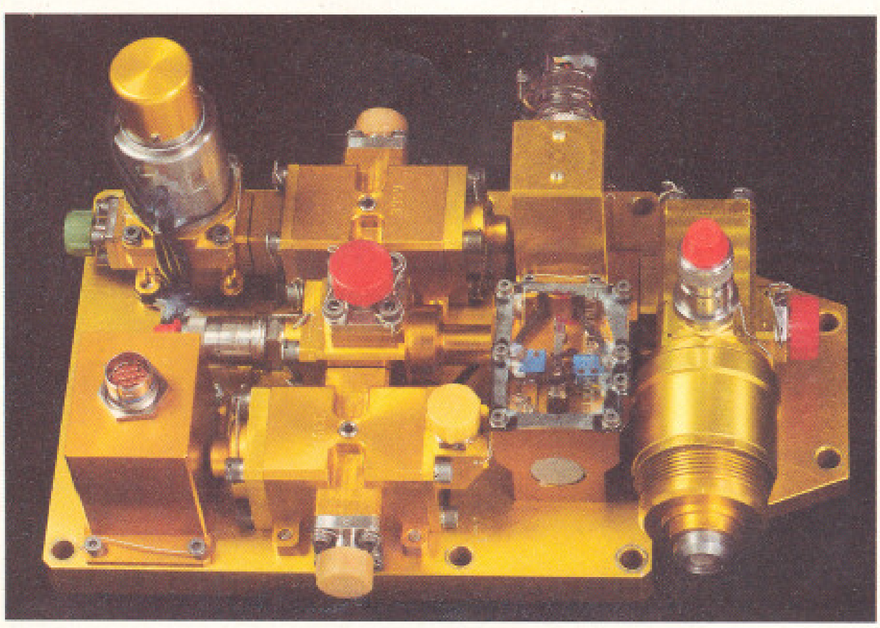
Second stage separation test



Heatshield separation test



Pogo command module

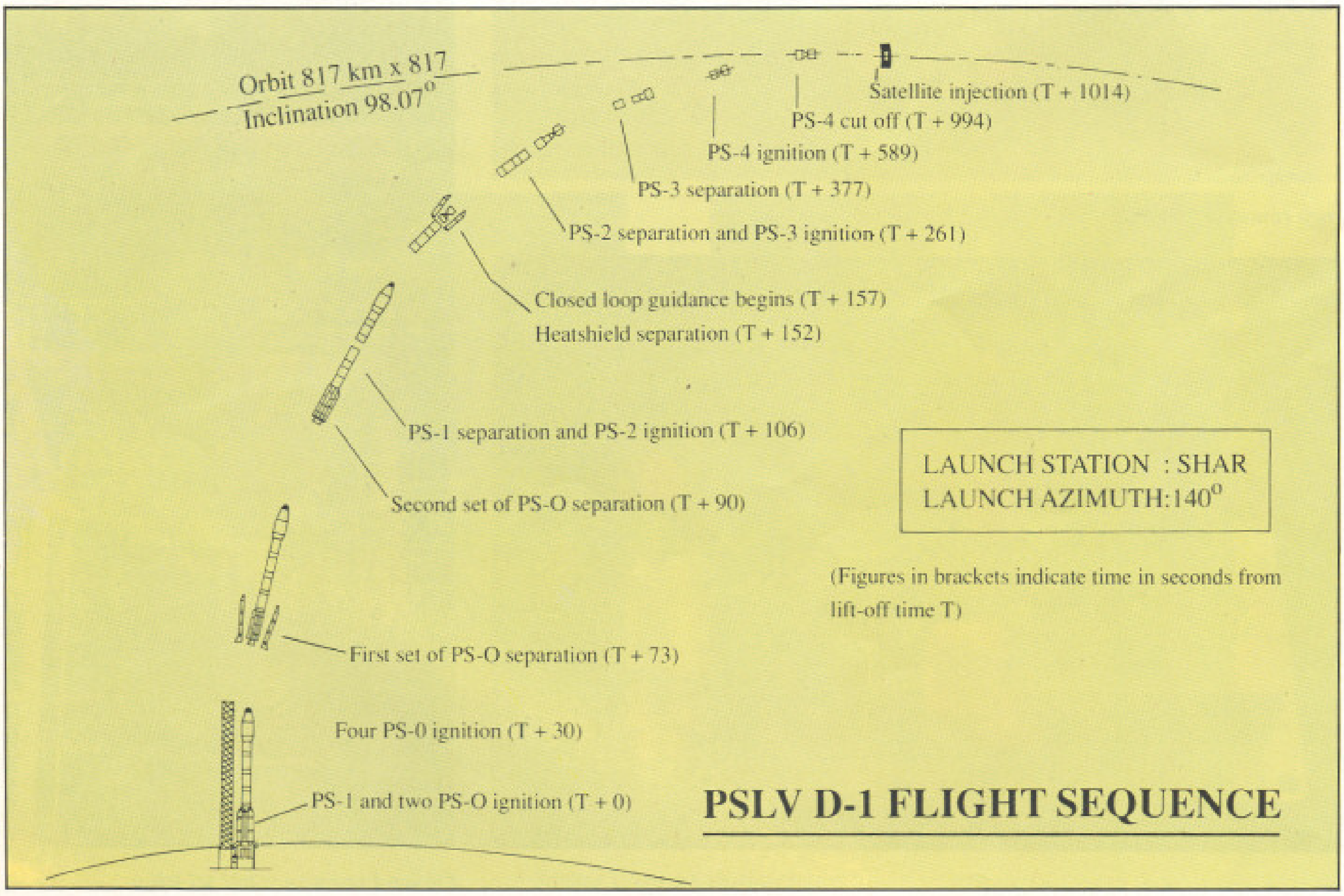


Components module of fourth stage

Ground resonance test set-up

Fourth stage and satellite stack test

The success of PSLV, technologically the most challenging endeavour till date, will mark an important milestone in India's effort to achieve operational capability in the satellite launch vehicle. □

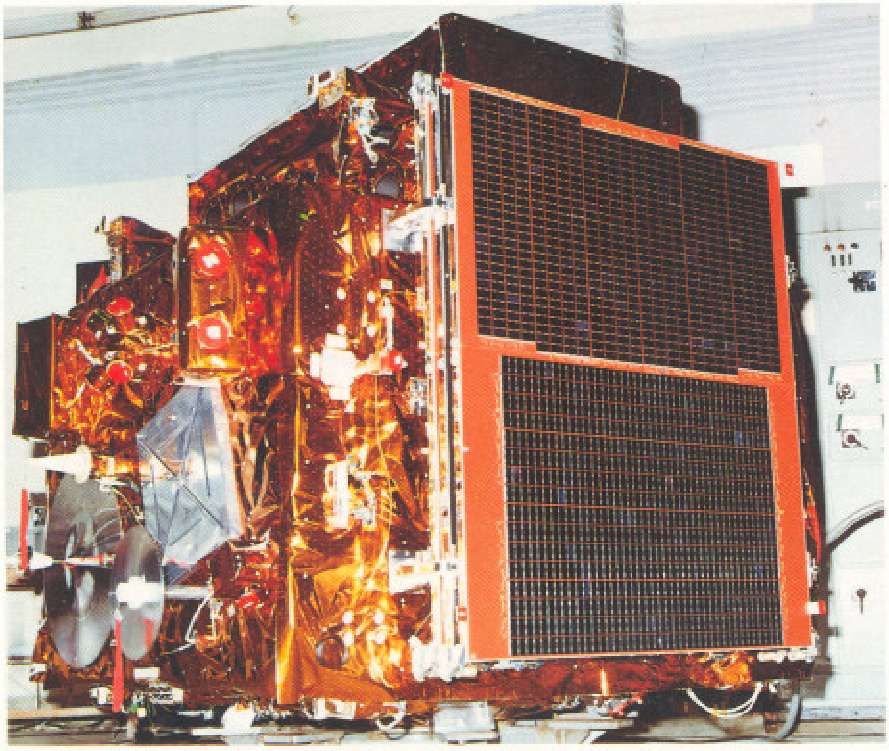


PSLV STAGES AT A GLANCE

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core PS1 + Strapon PSOM 6 Nos	PS2	PS3	PS4
Propellant	Solid Propellant HTPB Based	UDMH+ N_2O_4	Solid Propellant HTPB	Bi-propellant MMH+ N_2O_4 Based
Propellant Mass (tonne)	128.0 + 6x9.0	37.5	7.2	2.0
Stage Mass (tonne)	220	43	8.4	2.89
Max. Thrust (kN)	4500 662x6	720	340	7.4x2
Burn time (sec)	97 45	149	76	415
Stage Dia(m)	2.8 1.0	2.8	2.0	1.3
Stage Length(m)	20 10	12.5	3.6	2.1
Control	SITVC for Pitch & Yaw, Reaction Control Thrusters for Roll. SITVC in 2 PSOMs for Roll Control Augmentation	Engine Gimbal for Pitch & Yaw, Hot Gas Reaction Control Motor for Roll Control	Flex Nozzle for Pitch & Yaw, PS4 RCS for Roll Control	Engine Gimbal for Pitch, Yaw and roll On-off RCS for coast phase control

IRS-1A

Completes Five Years

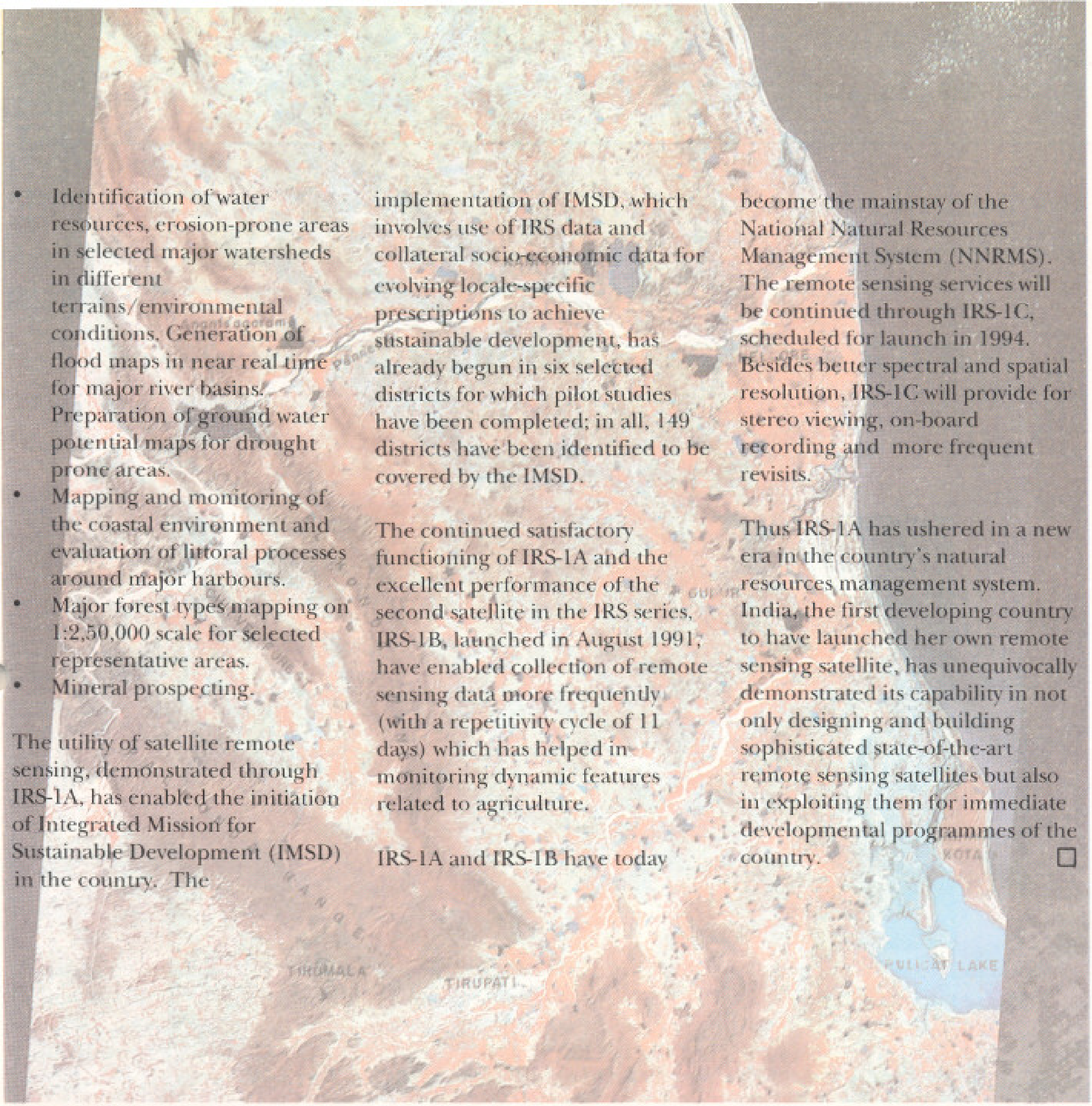


India's first operational remote sensing satellite, IRS-1A, has successfully completed five years in orbit. The 975 kg satellite, launched on March 17, 1988 by a Vostok rocket from the Baikonur Cosmodrome of the erstwhile USSR, was designed for three year's life but continues to function well even today. Orbiting the earth in a north-south direction at an altitude of 900 km, IRS-1A, with its two payloads, Linear Imaging Self-Sensors, (LISS-I and LISS-II) has been sending high quality pictures daily during the morning passes over India. The payloads are calibrated during the night-time passes over the country.

The satellite operations are being conducted from the Spacecraft Control Centre of the ISRO Telemetry, Tracking and Command Network (ISTRAC), Bangalore, through the ground stations located at Bangalore, Lucknow and Mauritius. The Data Reception Centre of the National Remote Sensing Agency (NRSA) at Shadnagar near Hyderabad has been receiving the IRS-1A data regularly which is processed at the NRSA facilities at Balanagar, Hyderabad and the data is distributed to several users all over the country. The data products are available in the form of photographs, computer compatible tapes, cartridges and floppies.

The successful operation of IRS-1A has opened up a number of application areas in remote sensing which are of direct relevance to India's development. The following projects have been completed:

- Large area crop acreage estimation of wheat, rice, groundnut, cotton and sorghum and their yield estimates.
- Mapping of saline/alkaline soil in the country on a 1:2,50,000 scale.
- Landuse/Landcover mapping of the entire country on a 1:2,50,000 scale and identification of culturable waste lands on 1:50,000 scale in specific areas.
- Urban sprawl maps of all major cities on 1:50,000 scale for planning their development.



- Identification of water resources, erosion-prone areas in selected major watersheds in different terrains/environmental conditions. Generation of flood maps in near real time for major river basins. Preparation of ground water potential maps for drought prone areas.
- Mapping and monitoring of the coastal environment and evaluation of littoral processes around major harbours.
- Major forest types mapping on 1:2,50,000 scale for selected representative areas.
- Mineral prospecting.

The utility of satellite remote sensing, demonstrated through IRS-1A, has enabled the initiation of Integrated Mission for Sustainable Development (IMSD) in the country. The implementation of IMSD, which involves use of IRS data and collateral socio-economic data for evolving locale-specific prescriptions to achieve sustainable development, has already begun in six selected districts for which pilot studies have been completed; in all, 149 districts have been identified to be covered by the IMSD.

The continued satisfactory functioning of IRS-1A and the excellent performance of the second satellite in the IRS series, IRS-1B, launched in August 1991, have enabled collection of remote sensing data more frequently (with a repetitivity cycle of 11 days) which has helped in monitoring dynamic features related to agriculture.

IRS-1A and IRS-1B have today become the mainstay of the National Natural Resources Management System (NNRMS). The remote sensing services will be continued through IRS-1C, scheduled for launch in 1994. Besides better spectral and spatial resolution, IRS-1C will provide for stereo viewing, on-board recording and more frequent revisits.

Thus IRS-1A has ushered in a new era in the country's natural resources management system. India, the first developing country to have launched her own remote sensing satellite, has unequivocally demonstrated its capability in not only designing and building sophisticated state-of-the-art remote sensing satellites but also in exploiting them for immediate developmental programmes of the country. □

Five Years of IRS-1A

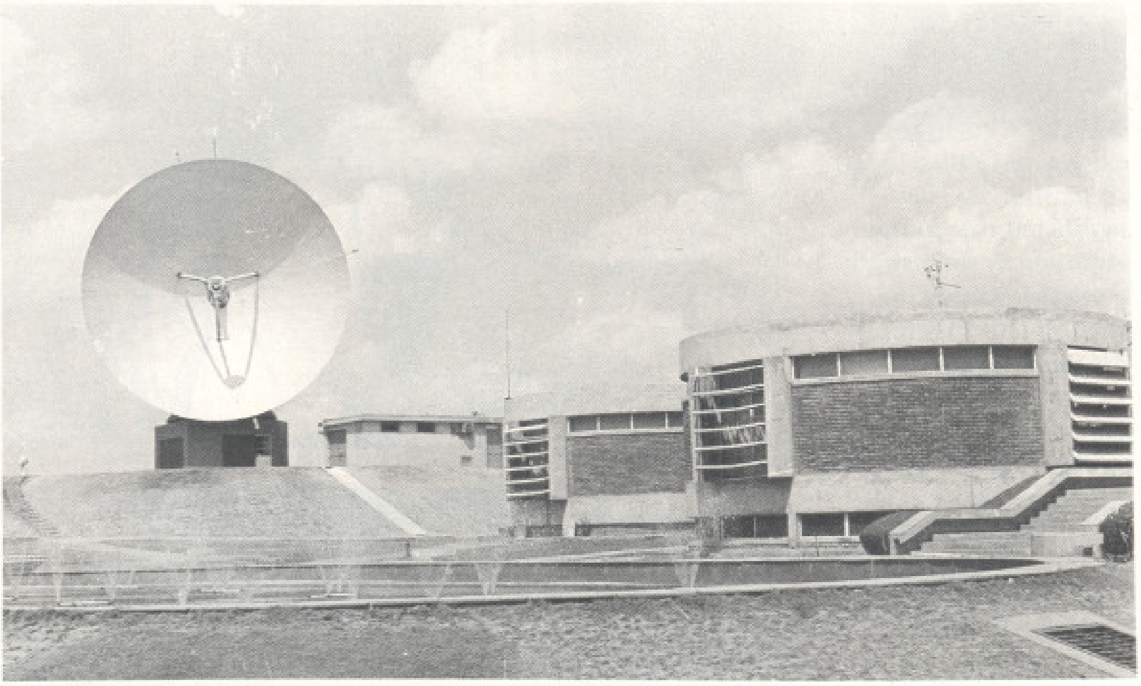
Number of orbits completed	25,470	Orbit trim manoeuvres	43
Number of payload cycles completed	82	Number of commands sent	1,05,000
Number of payload passes	3,700	Number of LISS-I scenes acquired	87,000
Number of payload calibration cycles	82	Number of LISS-II scenes acquired	3,48,000
Orbit correction operations			
— In-plane	13		
— Out of plane	7		

Book on Natural Resources Management Released

Shri P. Rangarajan Kumaramangalam releasing the book. Prof. U.R. Rao, Chairman, ISRO (left) and Prof. B.L. Deekshatulu, Director, NRSA (right) look on.

*A book entitled **"Natural Resources Management - A New Perspective"**, was released on October 20, 1992, by Shri P Rangarajan Kumaramangalam, Minister of State for Science & Technology at a simple function at the National Remote Sensing Agency, Hyderabad. The book, edited by Dr.R L Karale, has been brought out by the National Natural Resources Management System (NNRMS), Department of Space, Bangalore. Besides a foreword by Dr . Pranab Mukherjee, Deputy Chairman, Planning Commission (currently Commerce Minister), the book has a lead paper **"Remote Sensing for Sustainable Development - Indian Perspective"** by Prof U R Rao, Chairman, Space Commission. The book covers selected satellite remote sensing applications, mainly using data from the first Indian remote sensing satellite, IRS-1A, launched in 1988. Besides review papers dealing with historical developments in remote sensing applications in diverse fields, several case studies pertaining to geology, geomorphology, soil, land use, agricultural crops, forestry, oceanography and others have been covered in this 525 page volume.* □

ESCES
Completes 25 Years



One of the earlier photograph of ESCES

The Experimental Satellite Communications Earth Station (ESCES), renamed as Ahmedabad Earth Station (AES) in 1975, at the Space Applications Centre, has completed twenty-five years of continuous operation. The establishment of ESCES was a major step towards the use of space technology for national development. The station was started with the objectives of gaining experience in establishing an earth station for satellite communications, conducting satellite communication experiments and imparting training to scientists and engineers both from India and other developing countries. The establishment of ESCES also led to large scale production of television receivers, various up-linking earth station equipment, development of test and calibration facilities and a TV studio.

When the technology of satellite communications was making rapid strides, the Department of Atomic Energy (DAE) in India and the International Telecommunication Union (ITU) and United Nations Development Programme (UNDP) decided to establish ESCES at "Jodhpur Tekhra" near Ahmedabad in 1965. The project became operational in 1967 when the first contact was made with ATS-2 satellite of NASA. The entire work of installation and commissioning of ESCES, including the 14 metre diameter antenna was completed in a record time of 87 days.

The success of the Indian scientists and engineers in completing ESCES project paved the way for the setting up of an earth station with a giant 29 metre diameter fully steerable antenna at Arvi near Poona for Overseas Communication Services (OCS) via INTELSAT satellites. Later, during 1975, the Satellite Instructional Television Experiment (SITE) provided an opportunity to demonstrate the use of satellite television for the education of rural population in the country. The Delhi Earth Station (DES) was established in July 1975 for the SITE programme.

During the last twenty five years, ESCES has seen a number of changes to meet the demands of many ISRO projects. The earth station has been used to conduct new communication experiments, training of personnel, etc. These facilities were also used for conducting certain astronomical studies during 1979-80.

Recently, the ESCES facilities have been used for conducting a number of experiments using the INSAT-1B satellite which having completed its design life of 7 years in 1990 is still on. Some of these experiments include Satellite News Gathering (SNG), talk-back Direct Reception System (DRS) for interactive educational TV, teleconferencing, data transfer and characterisation of antennae and receivers, etc.

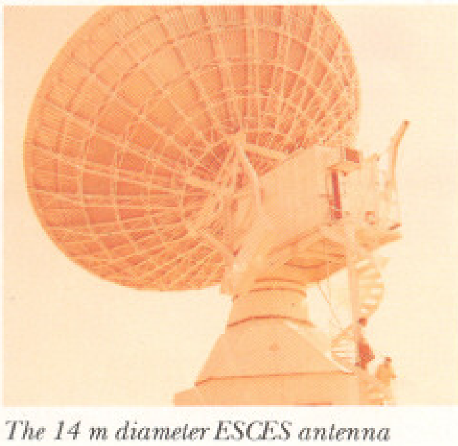
The year 1992 also marks the completion of 20 years by the Space Applications Centre (SAC). During this period, SAC has played a significant role in the space programme by successfully designing and developing the communications and VHRR payloads for the indigenous INSAT-2 series of satellites, the first of which, INSAT-2A, was launched in July 1992; besides, SAC has developed the camera payloads for the Indian Remote Sensing Satellite (IRS) series, two of which, IRS-1A and IRS-1B, are now in orbit.

SAC celebrated the event through an Open-House programme in which visitors were allowed to go around the campus. An exhibition was also organised during December 5-10, 1992 with displays on the various activities of SAC and DECU. The Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram, also participated in this exhibition. Besides, popular lectures by eminent scientists, model making and quiz competitions for college students were also organised.

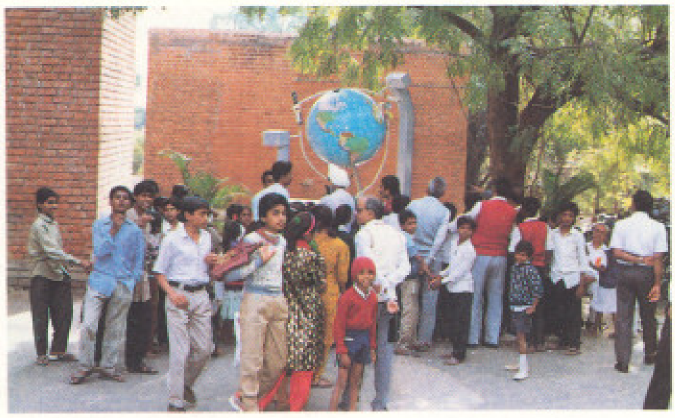
Addressing the former and present SAC employees, Prof. U. R. Rao, Chairman, Space Commission, who presided over a function on December 31, 1992, said that the dreams of Dr. Vikram Sarabhai and Dr. Homi Bhabha were not only realised but even surpassed.

The late Prime Minister Smt. Indira Gandhi, at ESCES. The late Dr. Vikram Sarabhai (top) is also seen

ESCES, now 25 years young, stands today as the pioneering symbol of ISRO's commitment to bring the fruits of space research to the common man. □



The 14 m diameter ESCES antenna

The Celebrations. Prof. U.R. Rao handing over memento to Shri C.K. Tiwari, an old employee (left) and students going round the exhibition

Nostalgia!

Shri N Pant, Member, Space Commission, who was instrumental in establishing ESCES, recalls his memories

It was early 1960s. Olympics at Tokyo had been shown live on TV in the USA using the experimental satellite SYNCOM. The impact was tremendous. However, there was still no operational system using satellite technology for communications. INTELSAT was only in the formative stage. At that time, it was a good fortune for the country to have had visionaries like Dr. Vikram Sarabhai who could see the immense potential of this powerful tool in telecommunications and broadcasting. A decision was taken in 1964 to set up an Experimental Satellite Communnications Earth Station (ESCES) to gain experience in this technology and to exploit the same for meeting our future requirements in this new field. The Department of Atomic Energy, which was a premier scientific and technological department at that time, was entrusted with this responsibility.

A project was set up in 1965 at Ahmedabad to plan and execute the ESCES. By the middle of 1965, about half a dozen of us had gathered at Ahmedabad with a small support staff to work on the project. Gradually the team expanded as the initial activities in the project gained momentum.

We were very few and activities were multifarious. Many of us had to put on different caps at different times as a driver or a helper or a technician to ensure that things move on. It was our learning phase. We were all new to this technology although we had had some experience in the fields of microwave systems and other communication networks. We had therefore to go through whatever literature we could get hold of in this field. At the same time, many project related activities such as acquisition of land, planning and construction activities, preparation of project reports and interaction with Indian industry were also taken up. A twelve hour schedule with hardly one or two Sundays off in a month was the norm. It was all very hectic, but we enjoyed it.

We were enthusiastic and energetic in our pursuit of this new technology but badly needed a friend, guide and philosopher. The United Nations Development Programme (UNDP) and International Telecommunications Union (ITU) helped us with both expertise and equipment. Our first challenge was the formulation of job requirements for the recruitment of the ITU expert to assist in preparing the project report. Expertise in the areas complementary to the ones already available in the country was what we were looking for. The strategy therefore was to select a person who had access to various specialists in this area. We found one ideally suited for our purpose, Mr Phillip Rubin. The project proceeded full-steam ahead in preparing the project report. We got a complete earth station with a 14 metre fully steerable antenna and associated transmit-receive chains from NEC, Japan. Its installation was completed in a record time of 87 days and the station became operational in the last week of June 1967.

ESCES was to work with NASA's ATS-2 spacecraft. Unfortunately, ATS-2 did not achieve its desired orbit and was tumbling. However, we succeeded in sending few video signals with make-shift video equipment via ATS-2 to the Radio Research Laboratories — Kashima station in Japan. It is very difficult to describe the thrill we experienced when we received the return signals via ATS-2 spacecraft and Kashima confirmed that they too received the signals. The project phase for ESCES was complete and our next job was to plan for achieving the objectives for which ESCES was set up.

The objectives in setting up the ESCES were:

a. To establish an experimental facility in satellite communications in the country.

b. To train scientists/engineers in India and other developing countries in satellite technology and its applications.

c. To form a nucleus for future indigenisation of various hardware and technologies (including software) used in this area.

d. To provide a laboratory to test out various applications of satellite technology - mainly in the field of communications.

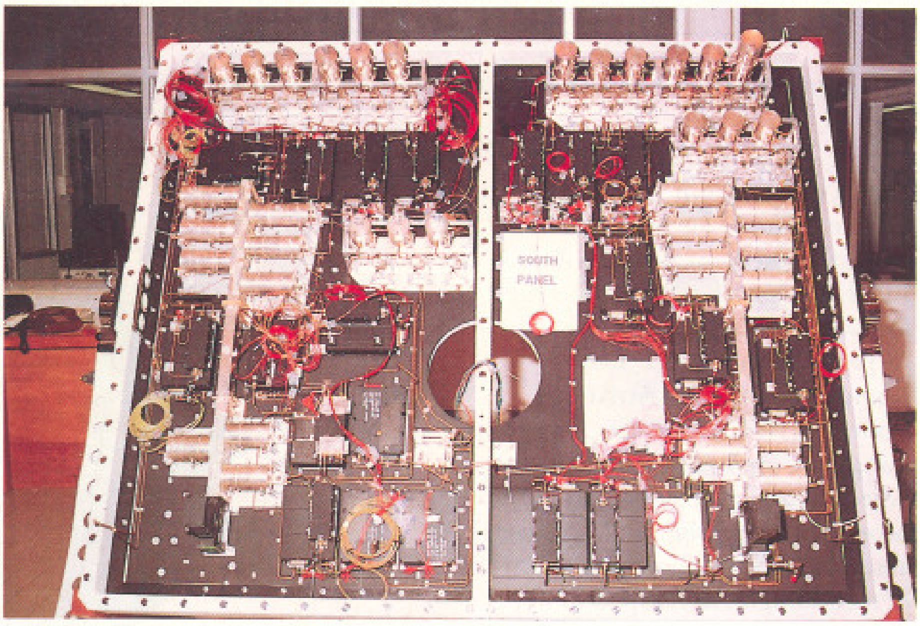
The first objective was amply met by the commissioning of the ESCES. One only had to keep it updated with improved technologies to keep abreast with the latest in the field. The second objective, namely, training, was one of the main tasks right from the beginning. Many courses for Indian and foreign trainees have been conducted at ESCES. This training culture is still prevalent at the Space Applications Centre.

To describe even briefly what we have achieved in regard to the third and fourth objectives would need many pages. Let it suffice to say that the numerous projects successfully completed at ESCES and SAC stand as testimony to our efforts.

ESCES was followed by the Arvi Satellites Communications (ASCOM) project which was completed in 1972. The responsibility of setting up India's first Satellite Communication Earth Station for overseas telecommunications via INTELSAT was entrusted to ESCES by the Government. At one stage, it was

The present Ahemedabad Earth Station

even considered to award a contract on a turn- key basis to a foreign company. However, because of having already established ESCES and the experience gained in that field, a decision was taken in favour of doing it indigenously. In this project, a fully steerable 30 metre diameter antenna whose G/T ratio exceeded the specification INTELSAT G/T was fully indigenised. Most of the terminal equipment were procured from the Indian Telephone Industries (ITI) and integrated with other systems. This was in line with the philosophy to progressively indigenise the hardware used.



Communication payload developed by SAC for INSAT-2

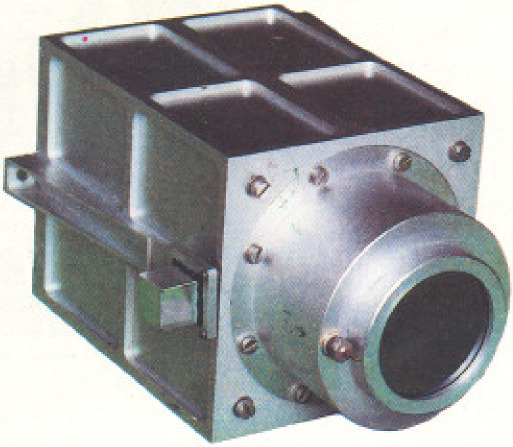
Then came the SITE (Satellite Instructional Television Experiment). It was the largest techno-sociological experiment ever undertaken to assess the effectiveness of satellite-based TV broadcast. We indigenised the earth station transmit and receive chains during SITE. Many other ground equipment such as Direct Reception sets, studio equipment, low power TV transmitters, etc. developed then are still being used extensively.

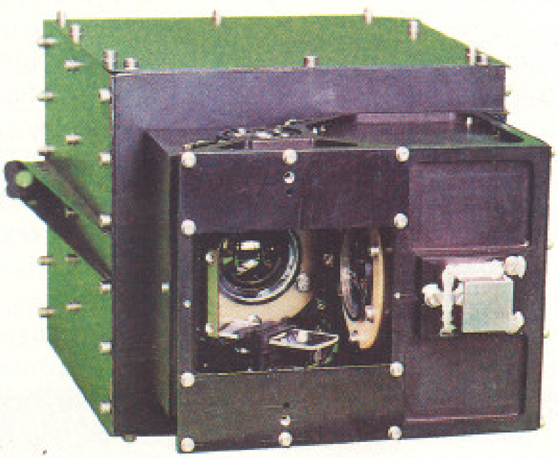
We had a number of other projects in satellite-based tele-communications such as Satellite Telecommunications Experiment Project (STEP) and APPLE Utilisation Project (AUP). These formed a very sound base for optimising the utilisation of satellite capability with INSAT, and provided an excellent insight to planners in these fields. All these experiments have been a motivator for INSAT and the present day expansion of our TV and telecommunications network via INSAT satellites. Above all , it gave us tremendous self confidence in taking on complex technologies hitherto not handled in the country. We have been able to initiate many new projects such as the satellite-based disaster warning system, meteorological data relay and the very novel concept of having a three-in-one-satellite - TV, Telecommunications and Meteorological payloads - INSAT. Today INSAT spacecraft have themselves been fully indigenised.

As we look back to the early sixties when we were debating whether or not to set up an Experimental Satellite Communications Earth Station and charter the course we have since followed, one cannot help getting nostalgic about these yester years. We have witnessed the growth of a family which is now well established in the field of satellite technology and its wide applications. We have a younger generation, which is much better trained now than we were in the early 1960's and on whose shoulders, we can safely place the responsibility to see that this technology grows further to meet the exciting challenges of future. I have no doubt that when we gradually fade away from the scene this family will continue to blossom to take on new challenges in this ever expanding field. □

Antrix Corporation Established

Antrix Corporation Limited, a private limited company wholly owned by the Government of India, has been established as the Corporate Front of the Department of Space. The Company, located at Antariksh Complex, New BEL Road, Bangalore - 560 094, has the main objective of marketing space products and services in India and abroad. It will deal with transfer of technologies developed under the Indian space programme to the Indian industry and provide consultancy services. Antrix Corporation will also coordinate the space hardware and software production among ISRO and various Indian industries involved in the space programme. The company, with an Authorised Capital of Rupees Five crore (50 million) and an initial Paid up Capital of Rupees One crore, has Prof. U. R. Rao as the Chairman of the Board of Directors, which also includes very senior officials of the Department of Space and eminent industrialists.





Products from Antrix. Conical Scanning Sensor (top) and Scanning Earth Sensor for Satellites

The establishment of the Antrix Corporation is the culmination of efforts of the Indian space programme towards achieving self-reliance in the development of space technology for the national development. It is to be noted that the Indian space programme has already passed through experimental phases and entered the operational phase during the 1980s with the establishment of INSAT and IRS systems using indigenously built satellites. The country is on the threshold of having its own operational launch vehicles for remote sensing satellites through the development of Polar Satellite Launch Vehicle (PSLV) whose maiden launch is scheduled for 1993. The Geosynchronous Satellite Launch Vehicle (GSLV), Project which is in progress, will provide the indigenous capability to launch INSAT class of communication satellites from within the country. In the process of building the indigenous space capability, elaborate infrastructure has been set up under the Indian Space Programme, for the development of satellites, launch vehicles and associated ground systems. Various satellite and launch vehicle systems and subsystems and a range of ground tracking, telemetry and command systems as well as ground hardware and software for satellite communication and remote sensing application have been developed and proved. A number of Indian industries have been involved in these efforts. The Antrix Corporation will now provide access to the products and services of the Department of Space and the Indian industries involved in the Indian Space Programme. □

Products and Services Offered by Antrix Corporation

Launch Vehicle Related

- Solid and liquid propellants and propulsion modules
- Motor Cases, Structures, payload fairings
- Inertial Sensors - DTG, Servo accelerometer, etc.
- Engineering design and software
- Launch facilities
- Control systems and mechanisms

Spacecraft

- Structures
- Payload Systems
- Propulsion systems (Tanks and thrusters) etc.
- Power Systems
- TTC Systems
- AOCS, Momentum Wheels, Reaction Wheels, DTGS and Electro- Optical Sensors
- Thermal Systems
- Deployment Mechanisms

Ground Systems

- TTC Stations for Satellite
- Telecom earth stations in C & extended C-Band
- TVRO's
- Precision Coherent Monopulse C-band Radars
- Remote sensing - Data reception, processing and analysis Facilities, Digital and Photo-Interpretation Aids

Spin-Off Technologies

- A number of Technologies covering many disciplines (Chemical, Mechanical, Electronics, Optical) are available for transfer to Industry
- Consultancy in all the disciplines mentioned above.

Antrix Bags INMARSAT Study Contracts

INMARSAT, the international maritime satellite communications partnership of 67 countries, has awarded two contracts to Antrix Corporation. One of the contracts relates to definition of hand-held phone satellite system using low earth orbit satellites. Two parallel contracts have been awarded for this study. While Antrix has won the contract exclusively, the other contract has been awarded to M/s Alcatel Alliance Consortium made up of Aerospatiale (France), Alenia (Italy), Alcatel (France), and Deutsche Aerospace (Germany). INMARSAT is considering three satellite constellations, Geostationary (GSO), Intermediate Circular Orbit (ICO) and Low Earth Orbit (LEO) for the hand-held phone service. The GSO constellation studies have been contracted to General Electric Astro (USA) along with Matra- Marconi (France & UK), and Hughes Space & Communications (USA) along with British Aerospace (UK) and NEC (Japan). The ICO constellation study contracts have been awarded to Matra-Marconi (France & UK) along with GE Astro (USA) and TRW (USA).

The LEO system is expected to comprise a number of small satellites orbiting at about 1800 km.

The other contract awarded exclusively to Antrix Corporation relates to the design, implementation and evaluation of a small omni directional L-band/S-band/UHF antenna for INMARSAT-P hand-held phone.

Vikram Sarabhai's Name to be Inducted into the International Space Hall of Fame

The Space Centre of New Mexico, USA, has decided to induct Dr Vikram Sarabhai's name into the International Space Hall of Fame. By paying this great tribute to the late Dr. Sarabhai, who is considered the father of the Indian space programme, the Space Centre has recognised India among the family of nations represented in the International Space Hall of Fame. The International Space Hall of Fame, opened in 1976, is an institution established to honour those individuals who have made outstanding contributions to the exploration of space. The name of Dr. Sarabhai was proposed by Prof. U. R. Rao, Chairman, Space Commission, Government of India and has been approved by the Governor's Commission of the Space Centre.

Dr. Vikram Sarabhai was an outstanding scientist, an institution builder, a visionary as well as a dreamer. A man of indefatigable energy, Dr. Sarabhai has left his impression on various fields of human endeavour. All over India, there stand a number of institutions of learning, research and experimentation, which bear testimony to his great vision, his devotion to the cause of India's advancement and his dedication to promotion of knowledge.

As Chairman, INCOSPAR,

Dr. Sarabhai was mainly responsible for organising the space programme in the country, which was initially started under the Department of Atomic Energy in 1962. He set up the Thumba Equatorial Rocket Launching Station near Thiruvananthapuram and initiated the programme for the manufacture of the French Centaure sounding rockets in India. With the firm belief that only space technology can rapidly transform India's stagnant society by enabling the country to improve its communications, education and management of natural resources to meet the increasing demands of its growing population, Dr. Vikram Sarabhai initiated the Indian space programme with clear, application-oriented goals. It was his vision which made it possible for India to conduct the Satellite Instructional Television Experiment in the country using the United States' Application Technology Satellite, ATS-6, during 1975-76, which is hailed as one of the largest socio-economic experiments in the world.

The space programme in the country has today matured into a full-fledged operational system providing, through INSAT-1 and INSAT-2 satellites, vital services in telecommunication, TV broadcast and meteorological services including disaster warning. Likewise, the two Indian Remote Satellites, IRS-1A and IRS-1B, are providing critical information required for monitoring and management of natural resources. The successful flight of ASLV-D3 launch vehicle in May 1992 and the advanced status of realisation of PSLV as well as the initiation of the work on GSLV, have put India on the threshold of having its own operational launch vehicles.

The space programme in India is considered by several countries all over the world as one of the most successful in using space technology as an effective tool for the upliftment of its society. The induction of Dr. Sarabhai's name in the International Space Hall of Fame is a recognition of the success of the Indian space programme.

Dr. Paul Heney, "the Voice of NASA," Sergei Krikalev, the last Soviet Cosmonaut, Dr. Martin Jaenke, pioneer in inertial rocket guidance systems and Richard M. Mullane, Space Shuttle astronaut, are also to be inducted into the Space Hall of Fame along with Dr. Vikram Sarabhai this year. The induction ceremony will be held during October 1-3, 1993. □

Dr Kasturirangan Elected Chairman of COSPAR Panel

Dr. K Kasturirangan, Member, Space Commission and Director, ISRO Satellite Centre, Bangalore, has been elected as the Chairman of the COSPAR Panel on Space Research in developing countries for the period 1992-96. Dr. Al-Mashat (Iran) and Dr. M E Machado (Argentina) are the two Vice-Chairmen of the Panel. An important body of the International Council of Scientific Union (ICSU), COSPAR is responsible for organising international symposia and workshops for presenting the results of space and associated ground-based experiments.

The primary objectives of the Panel are:

- to advise, plan, and, in selected cases, implement space activities that will meet the short and long term needs of developing countries, taking due note of their individual needs and constraints,

- to enable the formation of a local critical mass of space scientists and technologists of a high professional level, such that necessary expertise and manpower will be developed for increasing self-reliance, and to ensure the access of these experts to government decision makers,

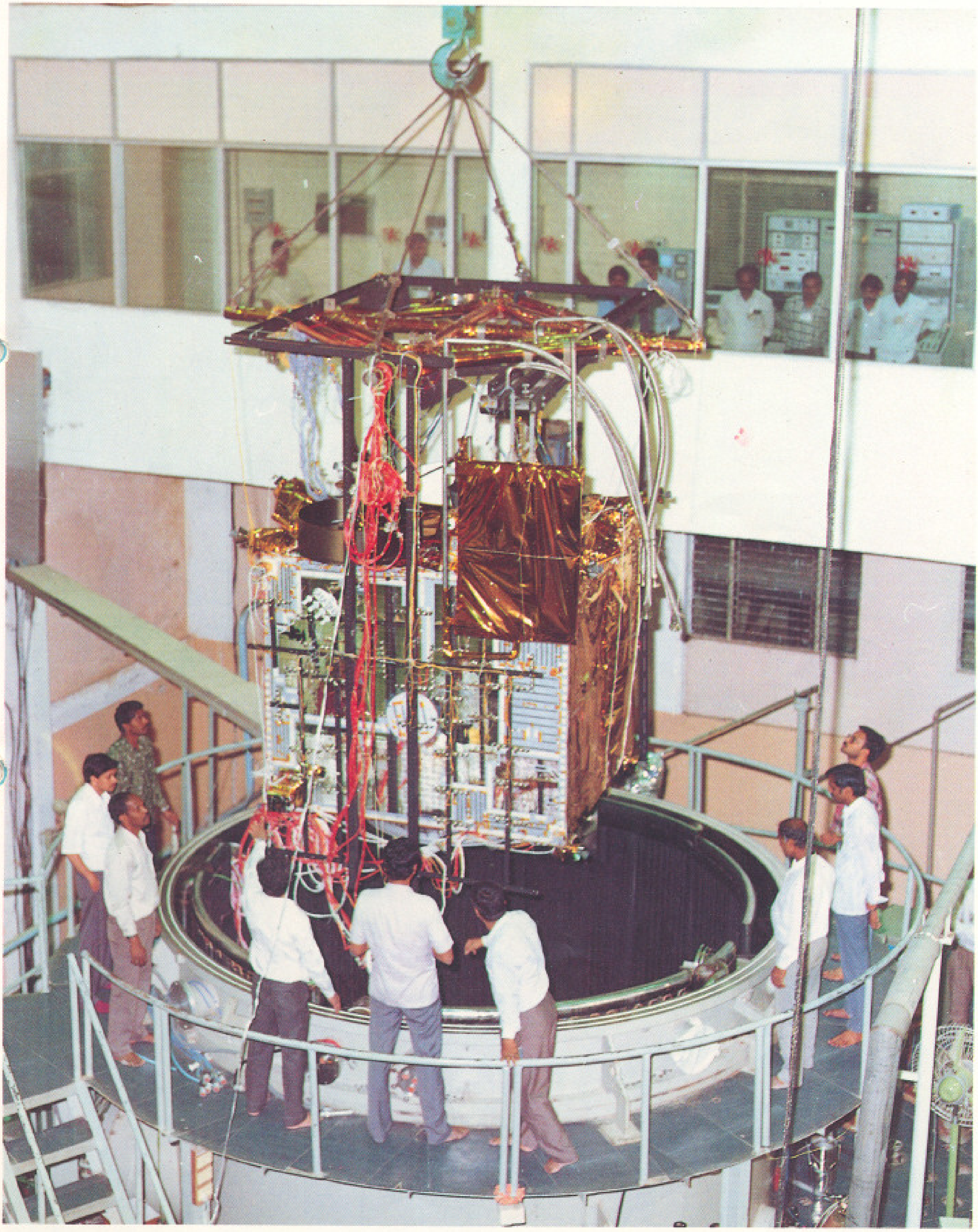
- to arrange, generally through COSPAR and the UN Agencies, co-operation with developed countries in a manner that enables the right kind of assistance and advice to be given to developing countries, recognising the special situation and long term interests of each country,
- to help in increasing cooperation between developing countries,

- to assist, where necessary, the preparation of an approach and a strategy for a national plan on space research for any interested developing country,

- to provide liaison between COSPAR and developing countries which are still not members of COSPAR and arrange for support of the kind described above. This may lead to their becoming members of COSPAR and, more importantly, the utilisation of space research in their own development efforts,

- to promote a channel of communication between scientists of developing countries, and also between developing and developed countries, on space research. □

INSAT-2B being loaded for thermovac test at ISRO Satellite Centre. The satellite is to be launched shortly by the Ariane launch vehicle



A view of the Mobile Service Tower and assembly mock-up of PSLV at SHAR Centre, Sriharikota