July-Sept. '97

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

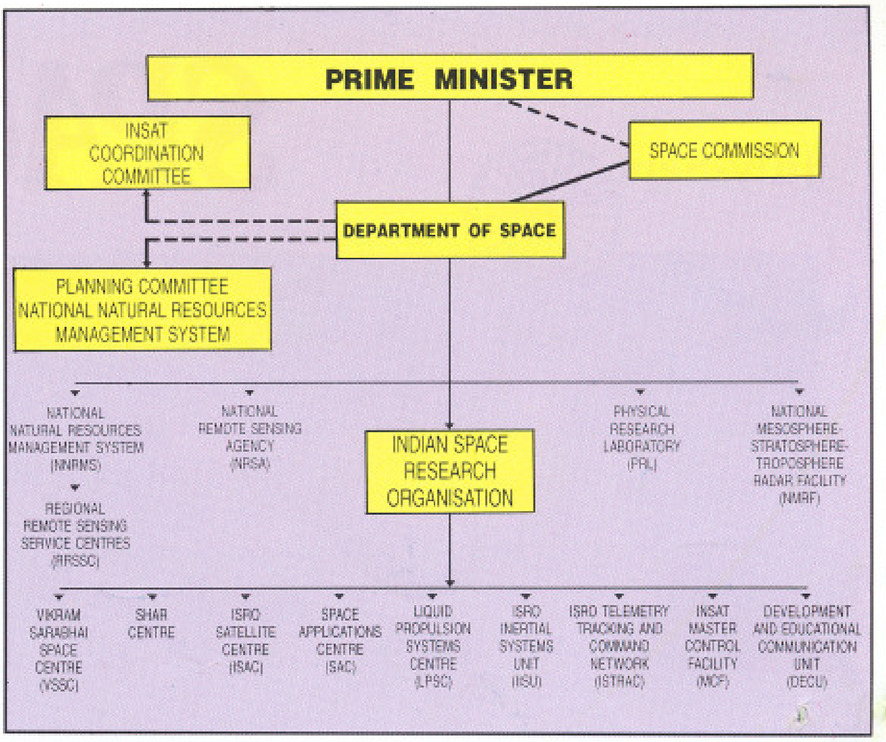
The Indian Space Programme

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.

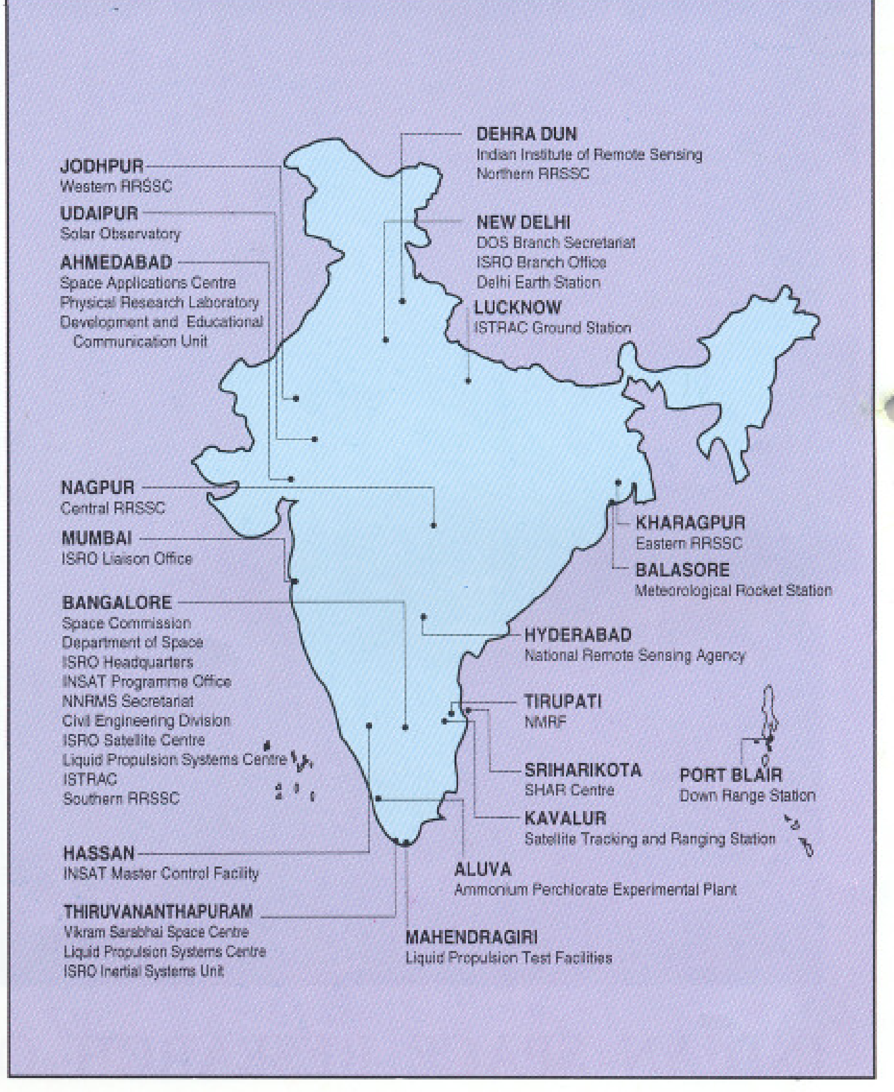
The Indian Space Programme is directed towards the goal of self-reliant use of space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological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



Space Centres and Units in India



FRONT COVER:
PSLV-C1 lifts-off with IRS-1D on board

EDITOR
S. Krishnamurthy

PRODUCTION ASSISTANCE
B.C. Suryaprakash

July-Sept. '97

'SPACE india' is published quarterly by the Indian Space Research Organisation for limited circulation. Articles appearing in SPACE india may be reproduced accompanied by the credit line *"Reprinted from SPACE india"* along with the date of issue.

Editorial/Circulation Office:

Publications & Public Relations Unit, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore - 560 094, India.

Printed at M/s. Carto Prints Pvt. Ltd., Bangalore, India.

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PSLV Launches IRS-1D

On September 29, 1997, as the entire nation watched on television, India's Polar Satellite Launch Vehicle, PSLV, roared towards the sky carrying on board IRS-1D, one of the most sophisticated civilian remote sensing satellites in the world. About 19 minutes later, IRS-1D had been placed into orbit. The capability to orbit 1,200 kg class satellites into polar orbit using an indigenously built vehicle was thus demonstrated; so far, operational remote sensing satellites, IRS-1A through IRS-1C, had been launched using erstwhile USSR/ Russian rockets. The Prime Minister, Mr I K Gujral, who witnessed the launch from Sriharikota Range, aptly said that the mission marked a major milestone in the country's fiftieth year of independence. Governor of Tamil Nadu Ms M Fathima Beevi, Chief Minister of Andhra Pradesh, Mr N Chandrababu Naidu, Union Minister for Information and Broadcasting, Mr Jaipal Reddy and several other dignitaries also watched the launch.

Prime Minister Mr I K Gujral (11th from right) poses for photograph in front of PSLV-C1. On his left are: Ms M Fathima Beevi, Governor of Tamil Nadu, Mr N Chandrababu Naidu, Chief Minister of Andhra Pradesh and Mr C Subramaniam, Former Governor of Maharastra (in white dhoti). On his right are: Mr Jaipal Reddy, Union Minister for Information and Broadcasting and Dr K Kasturirangan, Chairman, ISRO.

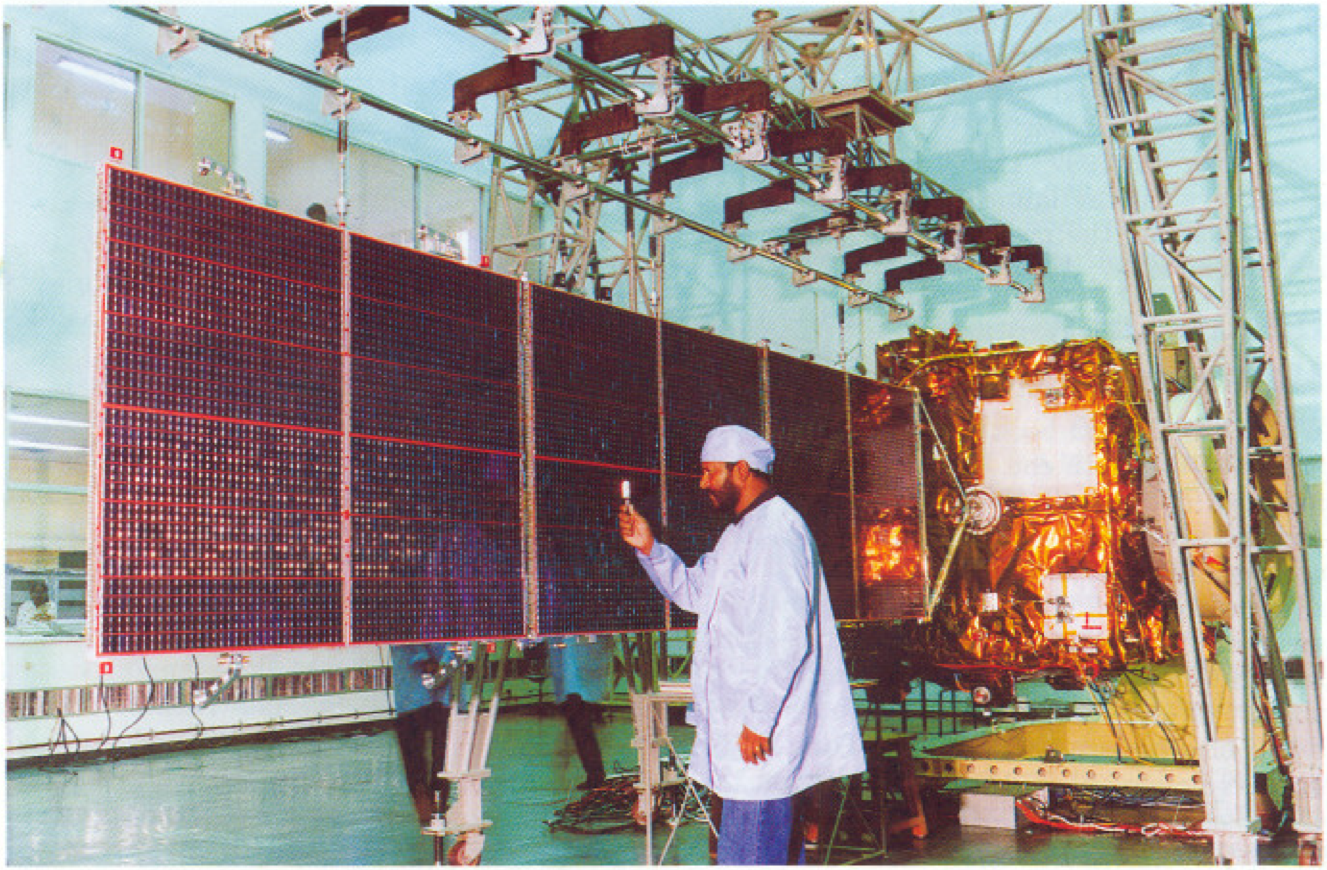
Shortly after separation from the launch vehicle, the Spacecraft Control Centre of the ISRO Telemetry, Tracking and Command (ISTRAC) network took control of the satellite, through its network of ground stations around the world. The solar panels of IRS-1D were unfurled automatically by an on board sequencer and the satellite was put in a 3-axis stabilised mode.

The 294 tonne 44.4 metre tall PSLV lifted off from the launch pad at Sriharikota at 10:17 am with the ignition of the first stage along with four strap-on motors. The remaining two strap-on motors ignited about 25 seconds later. It may be recalled that in the previous flights the core first stage and only two of the six strap-on motors were being ignited at lift-off and the remaining four ignited about 30 seconds later. This change of ignition sequence has enabled substantial improvement in the payload capability of PSLV.

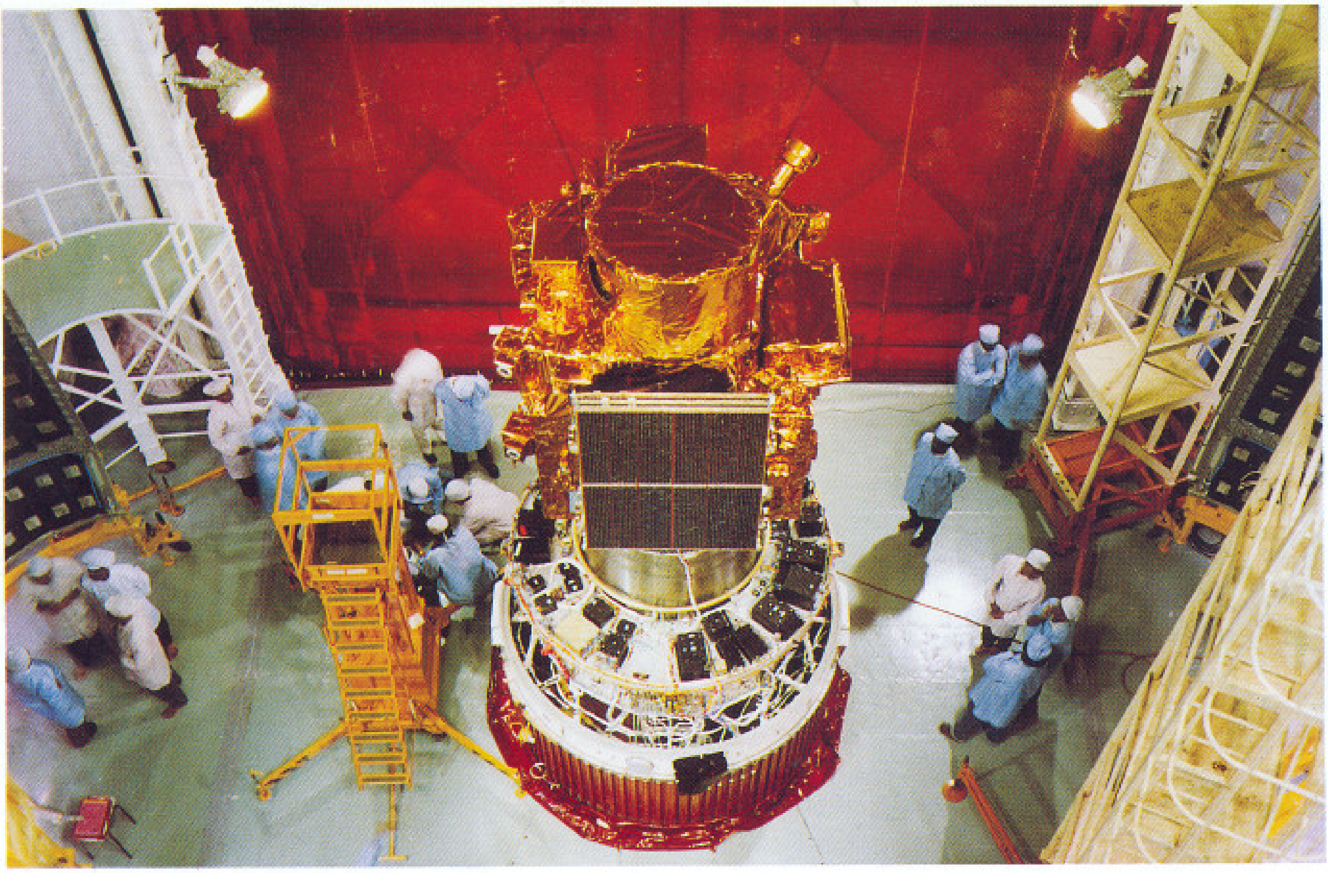
In the flight sequence, the first set of four strap-on motors separated as planned at 68 seconds after lift-off and the second set of two strap-on motors separated at 90 seconds. The first stage separated at 119 second and the second stage ignition occurred immediately. The heat-shield was jettisoned at 159 second as planned at an altitude of about 128 km after the launch vehicle had cleared the dense atmosphere. The second stage separation and the third stage ignition occurred at 282 second and the third stage separated at 501 second from lift-off. The last stage ignited after a long coasting at 602 second. The fourth stage cut-off occurred at 1037 second, followed by the injection of IRS-1D into orbit.

The closed-loop guidance system came into effect at about 168 second after lift-off as planned and guided the vehicle till the satellite injection. The spacecraft was placed in orbit in a 3-axis stabilised mode with guided injection.

PSLV-C1 vehicle assembly in the Mobile Service Tower had commenced on July 20, 1997 and the entire vehicle had been stacked by September 8, 1997. IRS-1D, after assembly and testing



A scientist checks, closely, the solar array of IRS-1D before its assembly with PSLV-C1.



IRS-1D mounted on top of PSLV-C1 equipment bay inside the Mobile Service Tower

at Bangalore, had reached SHAR Centre, Sriharikota, on September 1, 1997 and, after final checks, the satellite was mated with the launch vehicle on September 26, 1997. The countdown for the launch commenced on the morning of September 27, 1997.

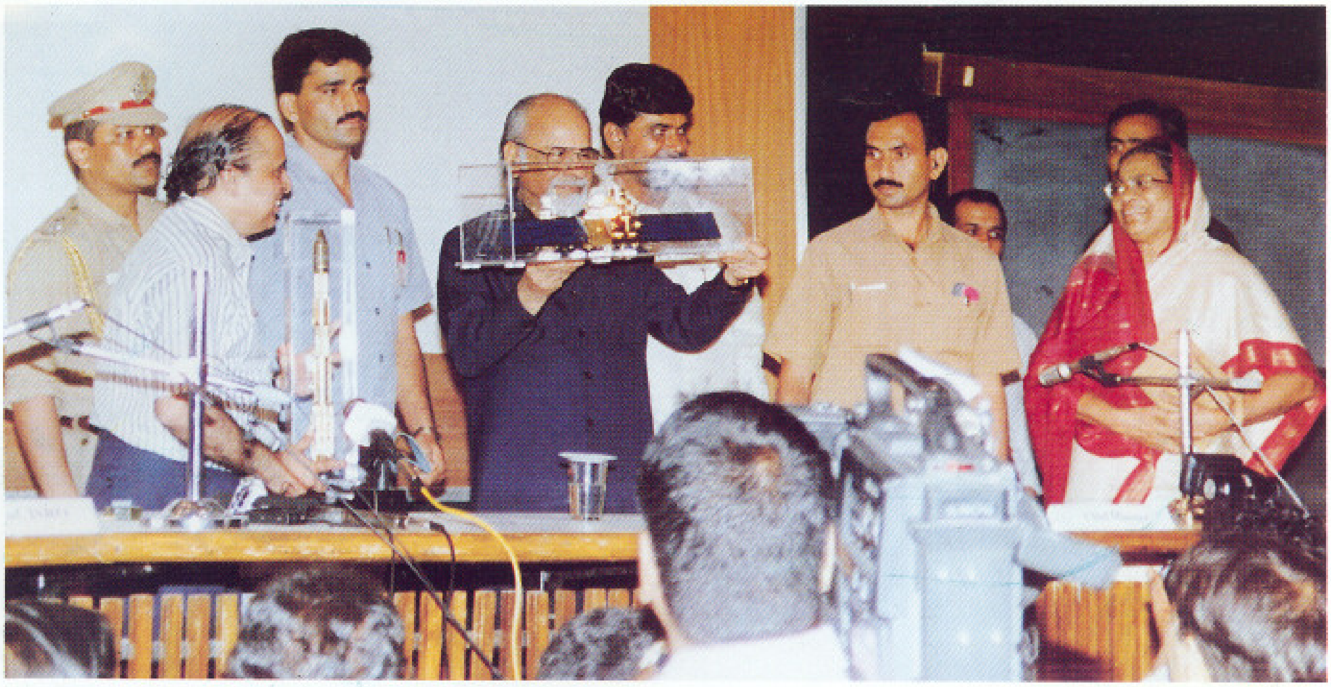
IRS-1D Orbit Manoeuvres

While IRS-1D had been put into the orbit with the intended apogee of 822 km and the inclination of the orbit was also within specified bounds, the perigee of the orbit was 301 km which was lower by about 500 km. This was the result of a minor shortfall in the velocity of injection of the satellite due to an under performance of fourth stage of PSLV — it was injected at 7316 m/sec instead of the required 7446 m/sec, a shortfall of 130 m/sec. But all the other systems performed well and PSLV had proved its capability.

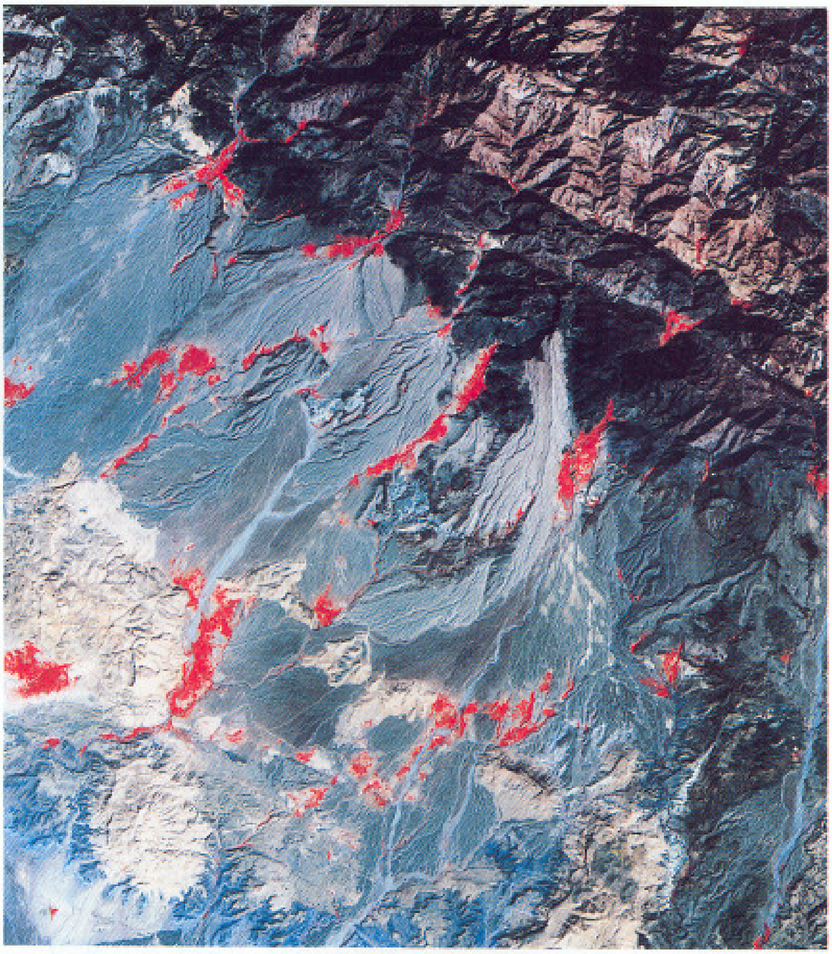
Considering the overall shortfall in the incremental velocity and the need to attain a functional sun synchronous orbit to carry out the remote sensing mission, carefully planned orbital manoeuvres were executed. The objective was to use the 84 kg of propellant on board IRS-1D optimally so that there is no compromise on the designed minimum life of three years for the satellite. Through firing the 11 Newton thruster in a step-by-step manner for a total duration of 5 1/2 hours, the satellite was placed in the planned orbit with a perigee of 737 km and an apogee of 821 km. There is sufficient propellant still on board to ensure three years mission life.

Cameras Switched on

All the three cameras on board IRS-1D, namely, the high resolution Panchromatic (PAN) Camera, the multi-spectral Linear Imaging Self Scanner (LISS-III) and the Wide Field Sensor (WiFS) were tested by commanding from the Spacecraft Control Centre (SCC) of ISTRAC, Bangalore on October 7, 1997. An analysis of the data received and processed by National Remote Sensing Agency (NRSA), Hyderabad, has confirmed that the cameras are performing well and the images are of high quality.



The precious gift: Prime Minister Mr I K Gujral accepting a model of IRS-1D from Chairman, ISRO immediately after launch of the satellite.



Color coded imagery obtained on October 7, 1997 from the multispectral camera system (LISS-III) of IRS-1D. The imagery with a ground resolution of 23 m, shows Southern Iran covering an area of about 28km X 28km. Geological features can be seen in northern part of the image and fine drainage pattern are visible in the central part. The red area represents vegetation

The PAN camera was tested for the first time at 10:44 am Indian Standard Time when the satellite was in its 120th orbit around the earth. The satellite was passing over Allahabad, Madurai and Tuticorin during the camera operation. The other two cameras, Linear Imaging Self Scanner (LISS-III) and Wide Field Sensor (WiFS), were tested during the subsequent orbit at 12:33 pm when the satellite was passing over the Gulf countries.

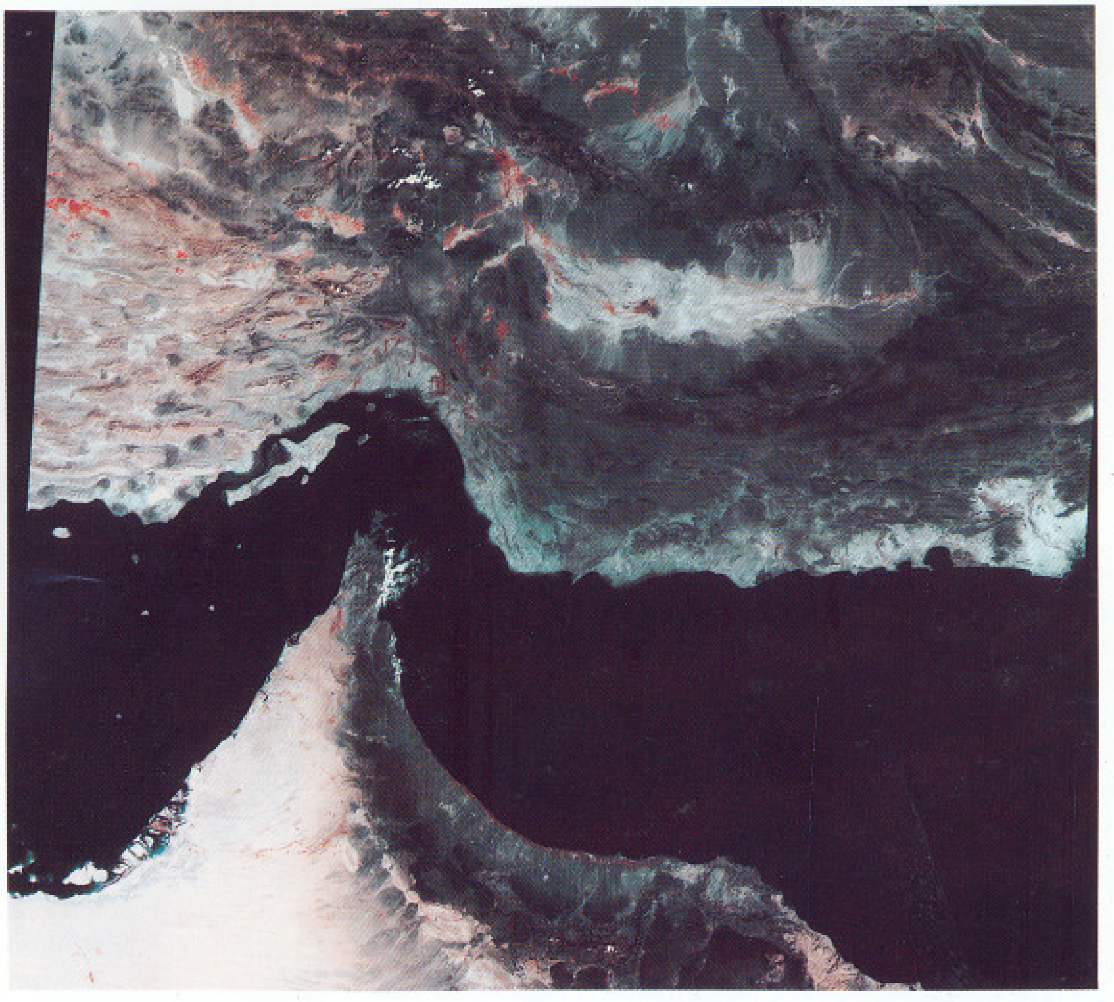
The PAN Camera of IRS-1D is a high resolution camera with 5.8 metre ground resolution. LISS-III operates in four spectral bands in the electro-magnetic spectrum – three in Visible and Near Infrared (NIR) and one in Short Wave Infrared (SWIR) region. It provides a ground resolution of 23.5 metre in Visible and NIR bands and 70.5 metre in SWIR band. The third camera, namely, Wide Field

Picture taken by the Panchromatic Camera (PAN) of IRS-1D on October 7, 1997 showing part of Tuticorin Town in Tamil Nadu. The picture which has a 5.8 metre ground resolution clearly shows rectangular salt pans. The regulated drainage system can also be seen besides built up structures.

Sensor has a ground resolution of 189 metre.

Earlier, the following day of the launch (September 30, 1997), the steering hold-down mechanism of the Panchromatic camera (PAN) on board IRS-1D had been released during the 16th orbit of the satellite by commanding from the Spacecraft Control Centre of ISTRAC at Bangalore. This operation enables the PAN camera to be steered up to $\pm 26°$ with respect to nadir position in steps of 0.1° thus, making it possible to take the imagery of the same area from two different angles providing stereo imageries. The high resolution stereoscopic data enables generation of digital elevation models and orthophotos.

IRS-1D is identical to IRS-1C launched in December 1995 but for a few improvements based on the in-orbit performance of IRS-1C; inclusion of a Satellite Positioning System (SPS) for precise orbit determination, on-board attitude determination using star sensor, use of improved version of Charge Coupled Device (CCD) in the Short Wave Infrared band, employment of surface tension type fuel tanks for the reaction control systems, are some of these improvements.



Colour Coded imagery obtained from the Wide Field Sensor (WiFS) of IRS-1D on October 7, 1997. The picture was taken over Iran-Oman-UAE region. The imagery covers an area of about 800 km X 800 km and has a ground resolution of 188 m. The narrow part of the ocean region appearing in black is the Strait of Hormuz.

IRS-1D is being monitored and controlled from the Spacecraft Control Centre of ISTRAC with a network of stations at Bangalore and Lucknow in India and also from the ISTRAC station at Mauritius. External ground stations at Bearslake near Moscow, Weilheim in Germany and Pokerflat in USA are providing support for the satellite operation and health monitoring as well as tracking support. During the initial phases of the mission, TTC station at SHAR Centre also supports the mission. The data from IRS-1D will be received and processed by the National Remote Sensing Agency, Hyderabad.

India has the largest constellation of civilian remote sensing satellites today — IRS-1B, IRS-1C, IRS-1D and IRS-P3, are in operation. IRS-P3 had been launched during the third developmental test flight of PSLV in March 1996. The availability of data from IRS-1D cameras along with data from IRS-1C will further enhance applications capability pertaining to land and water resources management in the country. Under commercial agreements, IRS data is available to users all over the world. Already, the data is being received by ground stations located in North America, Europe and Thailand. A few more stations are expected to receive the data shortly.

The launch of IRS-1D by India's own launch vehicle, PSLV-C1, coming in the 50th Year of India's Independence, assumes significance as it represents a major landmark in the technological self-reliance of the Indian space programme. It is a major event in the 25th year of the establishment of the Department of Space. ◘

Launch Vehicle Development in India

Development of launch vehicle encompasses many branches of science and engineering and requires elaborate infrastructure. Even today, only a few countries possess the technology of launch vehicles. The subsystems of a launch vehicle need to withstand hostile flight environment but, at the same time, be of light weight. Years of developmental efforts are put to test in a few minutes of flight and there can be no margin for error.

Rocket development in India began with the establishment of Thumba Equatorial Rocket Launching Station (TERLS) near Thiruvananthapuram in 1963 for conducting scientific experiments in aeronomy and astronomy using rockets brought from outside. The first sounding rocket was a small 75 mm diameter Rohini, RH-75. Today, India operates a family of sounding rockets of diameter ranging from 200 to 560 mm and capable of carrying upto 200 kg payloads to an altitude of 300-400 km to conduct scientific investigations.

Soaring higher! From small sounding rockets to PSLV with experimental Launch Vehicles SLV-3 and ASLV in between, ISRO has made a steady progress in its launch vehicle programme.

First Satellite Launch Vehicle of India, SLV-3

India's first experimental satellite launch vehicle, SLV-3, was successfully launched on July 18,1980 from SHAR Centre, Sriharikota when a Rohini satellite, RS-1, was placed in orbit. Conceived in 1969, SLV-3 was a 22 metre long, four stage vehicle weighing 17 tonne. All stages used solid propellant and it employed open loop guidance with stored pitch programme to steer the vehicle in flight along pre-determined trajectory. Sriharikota island, about 100 km north of Madras, was selected as the launch site for SLV-3 and for all subsequent launch vehicles, to take advantage of the earth's rotation. Located at 13 degree N latitude, the range is considered as the world's second best site for launching geosynchronous satellites; the best being Kourou in French Guyana which is situated at a latitude of 5 degree N.

The first experimental flight of SLV-3 had taken place in July 1979 but the mission was only partially successful. After the successful second flight, two more flights of SLV-3 were conducted in May 1981 and April 1983 to place in orbit Rohini satellites carrying remote sensing sensors. SLV-3 provided inputs for the vehicle and mission design, materials, hardware fabrication, realisation of solid propellant technology, control power plants, staging systems, inertial sensors, electronics, testing, integration and checkout and launch complex establishment at Sriharikota with associated ground instrumentation.

Augmented Satellite Launch Vehicle, ASLV

As a step towards realising polar and geosynchronous launch capability for operational class of satellites, development of Augmented Satellite Launch Vehicle (ASLV), was undertaken to act as a low cost intermediate vehicle to demonstrate critical technologies. With a lift-off weight of about 40 tonne, the 23.8 m tall ASLV was configured as a five stage solid propellant vehicle. The strap-on stage consisted of two identical 1 m diameter solid propellant motors similar to first stage of SLV-3. Other stages were same as those of SLV-3. Closed loop guidance, active from the ignition of the second stage motor to the separation of the third stage, was employed in ASLV while SLV-3 had used an open loop control system.

The first developmental flight test of ASLV took place in March 1987 but the mission did not succeed due to non-ignition of the first stage motor after the strap-on stage burn out. ASLV-D2 was launched on July 1988 but this mission also did not succeed. After a detailed failure analysis, a number of corrective actions were taken, many of them relating to transition between the strap-on stage and the first stage. They included better characterisation of vehicle, improved stability, introduction of on board detection of flight events and extensive simulations. With the incorporation of all these modifications, the third developmental flight, ASLV-D3, was successfully conducted on May 20, 1992 when SROSS-C satellite, carrying a Gamma-ray burst detector and an aeronomy payload was placed in the intended orbit. Another launch of ASLV, (ASLV-D4) was conducted on May 4, 1994 when the 113 kg SROSS-C2 satellite was put into orbit. ASLV provided valuable inputs to the development of PSLV.

Polar Satellite Launch Vehicle, PSLV

PSLV is the first operational satellite launch vehicle of India capable of launching 1200 kg class Indian remote sensing satellites into polar sun synchronous orbit. In the present configuration (PSLV-C1), the 44.4 metre tall, 294 tonne PSLV, has four stages using solid and liquid propulsion systems alternately. The first stage is one of the largest solid propellant boosters in the world and carries 138 tonne of propellant. It has a diameter of 2.8 m. The motor case is made of maraging steel which is indigenously produced. The booster develops a maximum thrust of about 4,630 kN. The first stage thrust is augmented by six strap-on motors, four of which are ignited on the ground. Each of these solid propellant strap-on motors, using indigenously produced Hydroxyl Terminated Poly Butadiene (HTPB) fuel and Ammonium Perchlorate oxidiser, produces 662 kN thrust.

The second stage employs indigenously manufactured Vikas engine and carries 40.6 tonne of liquid propellant — Unsymmetrical Di-Methyl Hydrazine (UDMH) as fuel and Nitrogen tetroxide (N_2O_4) as oxidiser. It generates a maximum thrust of about 725 kN.

The third stage uses 7.2 tonne of HTPB-based solid propellant and produces a maximum thrust of 340 kN. Its motor case is made of polyaramide (Kevlar) fibre. The fourth and the terminal stage of PSLV has a twin engine configuration using liquid propellant. With a propellant loading of 2 tonne (Mono-methyl hydrazine + N_2O_4), each of these engines generates a maximum thrust of 7.4 kN.

The metallic bulbous heat-shield of PSLV, 3.2 m in diameter, is of isogrid construction and protects the spacecraft during the atmospheric regime of the flight. PSLV control system includes: a) First stage; Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw, reaction control thrusters for roll and SITVC in two strap-on motors for roll control augmentation, b) Second stage; Engine gimbal for pitch and yaw and, hot gas reaction control for roll, c) Third stage; flex nozzle for pitch and yaw and PS-4 RCS for roll and d) Fourth stage; Engine gimbal for pitch, yaw and roll and, on-off RCS for control during the coast phase.

The inertial navigation system is the strap-down version with guidance system resident in the equipment bay. It guides the vehicle till the injection of spacecraft into orbit.

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 and C-band transponders, besides a host of power and signal conditioning packages. PSLV employs a large number of stage auxiliary systems for stage separation, heat-shield separation and jettisoning, etc.

PSLV project was initiated in 1982 and the first developmental test flight PSLV (PSLV-D1), took place on September 20, 1993. However the vehicle did not fulfill the mission of injecting the IRS-1E satellite, on board, into orbit primarily due to a software error in the pitch control loop of the on-board guidance and control processor. But most of the PSLV systems performed normally. The second developmental flight, PSLV-D2, on October 15, 1994, was a complete success when the vehicle injected the 804 kg remote sensing satellite, IRS-P2, into the desired orbits. During the third developmental test flight, on March 21, 1996, PSLV could place a 922 kg IRS-P3 satellite, in the intended 817 km polar orbit. With these two consecutive successes, PSLV became the first operational vehicle of India.

The first operational vehicle, PSLV-C1, launched on September 29, 1997, incorporated several improvements to enhance the payload capability to 1,200 kg which is the weight of IRS-1D launched by it. The major improvements include:

- increasing the solid propellant in the first core stage from 128 tonne to 138 tonne,
- increasing the liquid propellant loading in the second stage from 37.5 tonne to 40.6 tonne by stretching the stage tankages,
- replacing the metallic payload adopter by a CFRP adopter and
- effecting weight reduction in the vehicle equipment bay.

Besides, in the PSLV-C1 mission, four of the six strap-on motors were ignited on the ground along with the core first stage; in the earlier flights only two were ignited on the ground and the remaining a few seconds after lift-off. This revised sequence has given a substantial payload advantage.

Some of the major R&D efforts that went into the development of PSLV were related to solid propellant motors, liquid propulsion stages, materials and fabrication technology, inertial navigation and guidance systems, SITVC, flex nozzle for the third stage and gimbal control system of second stage, on board and ground software, telemetry, aerospace mechanisms, remote vehicle checkout, automatic launch processing systems, ground infrastructure for fabrication and testing, launch complex and tracking network.

Two more PSLV continuation flights have already planned over the next two years for launching IRS-P4 and IRS-P5 satellites. Fabrication of another three vehicles has also been initiated. The launch services from PSLV is now available for placing satellites of other countries either with a fully dedicated vehicle or as piggy-backs along with other satellite missions, depending on the requirments. A Korean satellite, KITSAT, is already planned to be flown on board PSLV-C2 as a piggy back.

Involvement of Industries and Institutions

With the Vikram Sarabhai Space Centre (VSSC) in Thiruvananthapuram acting as the lead-centre for launch vehicle development, major responsibilities for design and development of all launch vehicles are shared by the Liquid Propulsion Systems Centre (LPSC), also headquartered in Thiruvananthapuram and SHAR Centre in Sriharikota. The ISRO Inertial Systems Unit (IISU), Thiruvananthapuram is responsible for the development of inertial sensors and systems. The ISRO Telemetry, Tracking and Command Network (ISTRAC) is responsible for the telemetry and tracking support to all missions. A host of institutions and over 150 industries have contributed to the launch vehicle programme of ISRO. Industries, both in public and private sector, have been involved in the fabrication of a variety of hardware; light alloy structures for interstages, motor cases, electronic packages, heat-shield, precision coherent radars, etc. For example, the maraging steel, propellants and HTPB resin are now produced by the Indian industries.

On to Geosynchronous Satellite Launch Vehicle (GSLV)

India's Geosynchronous Satellite Launch Vehicle, GSLV, which is now under development for placing 2,000–2,500 kg INSAT class of satellites in geostationary transfer orbit will use many of the hardware developed and infrastructure established for PSLV with modifications where required. GSLV is configured as a three stage vehicle, the core being solid booster as in PSLV, the second stage being a liquid propulsion system as in the

GSLV, which is now under development, will enable India to launch INSAT class of satellites from within the country

PSLV with a propellant loading of 37.5 tonne. The upper stage is a restartable cryogenic engine with a propellant loading of 12 tonne (liquid oxygen and

Geosynchronous Satellite Launch Vehicle (GSLV)

Salient Features

Lift-off mass : 402 t

Height : 49m

Payload Mass : 2500 kg in GTO

Heatshield : Diameter: 3.40 m Length: 7.8 m Dynamic envelope: 3.05 m

	First Stage (GS-1)		Second Stage	Third Stage
	S125 booster	L40 strapon	(GS-2)	(GS-3)
Propulsion	Solid	Liquid	Liquid	Cryogenic
Length (m)	20	19.7	11.6	8.7
Dia (m)	2.8	2.1	2.8	2.8
Total mass (t)	157.3	45.6	43.0	15.0
Propellant mass (t)	129	40	37.5	12.5
Case/Tank Material	M250 steel	Aluminium	Aluminium	Aluminium
Propellant	HTPB	UDMH & N_2O_4	UDMH & N_2O_4	LH_2 & LOX
Burn time (s)	97	159	149	730
Thrust (kN) in vacuum	4801 (max.)	690	725	75.0
Control system	Multi-port SITVC	EGC	EGC for pitch & yaw control, Hot gas reaction thrusters for roll control	2 steering engines for thrust phase control & cold gas RCS for coast phase control

liquid hydrogen). The higher propulsion efficiency of the cryogenic stage in terms of its specific impulse makes it ideal for the upper stage of GSLV; specific impulse achievable with cryo fluids is of the order of 450 sec compared to 300 sec of earth storable and solid fuels, giving significant payload increase – for every one second increase in the specific impulse, the payload gain is of the order of 10 kg. While the initial flights of GSLV will use cryogenic stage procured from Russia, development of indigenous cryogenic stage has already been taken up for use in the subsequent flights; a one-tonne pressure-fed engine has already been successfully developed and tested. The first developmental test flight of GSLV is expected in 1998-1999.

Thus, India has come a long way in making the space programme self reliant by not only design-ing and building satellites like INSAT and IRS but also to launch them using indigenously designed and built vehicles. That, PSLV has already become opera-tional and substantial progress has been made in the develop-ment of GSLV, shows the maturity of Indian space programme to meet the growing needs of the country in a self-reliant manner. ◘

Cabinet Approves Policy Framework for Satellite Communications in India

Satellite communications has become a fundamental infrastructure of the communications network in India and hence needs to be properly regulated for an orderly growth. Further, Indian satellite systems have to comply with the various United Nations and International Telecommunications Union treaties and other international agreements to which India is a party.

Keeping this in view, the Union Cabinet has approved a policy framework for satellite communications in India.

The salient features of this policy are:

a) transponder capacity on INSAT system would be offered to non-governmental users also on commercial terms subject to capacity availability,

b) Indian private entrepreneurs will be permitted to establish commercial communication satellites and they will be assisted in registering such satellite systems and networks with the International Telecommunications Union (ITU) as Indian satellites, and,

c) operations from Indian soil will be allowed with both Indian and foreign satellites in accordance with the norms and conditions to be evolved, but Indian satellites will be accorded preferential treatment.

In so far as satellite-based broadcasting is concerned, the various provisions of the Satellite Communications Policy Framework would conform to the proposed Broadcasting Law.

With the far reaching decision of the Cabinet approving the policy framework, the Government will work out, in the next few months, the norms and conditions concerning the various aspects of the policy for its effective implementation. It is expected that the enunciation of the policy framework will lead to the development of a healthy and thriving communications satellite and associated ground equipment industry as well as satellite communications service industry in India. This will also open the INSAT system for wider usage. ◻

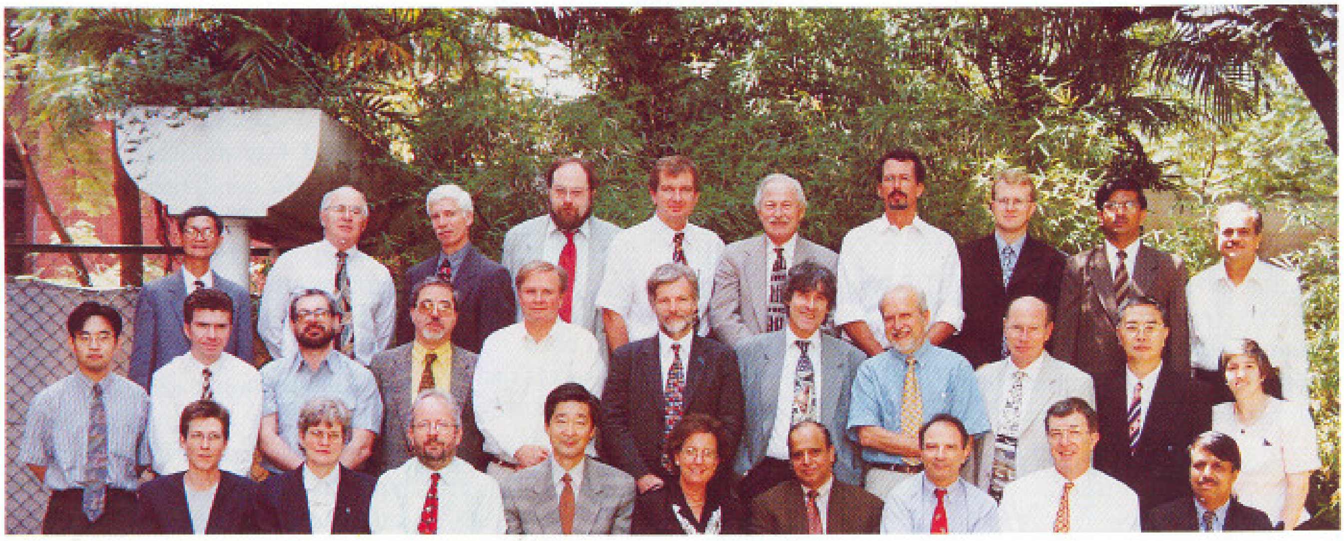
ISRO and Indian Institute of Science Launch Collaborative Educational and Research Programme

ISRO and the Indian Institute of Science (IISc), Bangalore, have formally launched a Collaborative Educational and Research Programme on "Satellite Technology and its applications". Under this programme, continuing education and Master of Engineering (ME) Programme will be started at IISc from the current year (1997). These programmes are aimed at developing the scientific/technical manpower required by the country's space programme and to upgrade the knowledge of the in-service scientists and engineers involved in the space programme. Besides, there is a possibility of collaboration with the International Space University, France. In addition, several research activities will be carried out in identified areas of Space Technology and Application.

ISRO and IISc have a longstanding cooperation and several research studies have been underaken by IISc for ISRO. A Space Technology Cell was started in IISc in 1982 and an Advanced Space Technology Laboratory was started in 1992 to service the research requirement of space programme.

The space programme in India has always tried to make the best use of the academic excellence that are available in the country's premier institutions like IISc and the new initiative will go a long way in meeting the technical manpower requirement of ISRO. ◻

International Meet on Earth Observation Satellites Held at Bangalore



Members of CEOS Working Group who met at Bangalore with Chairperson Ms Helen Wood, (first row centre) and Chairman, ISRO, Dr K Kasturirangan (4th from right)

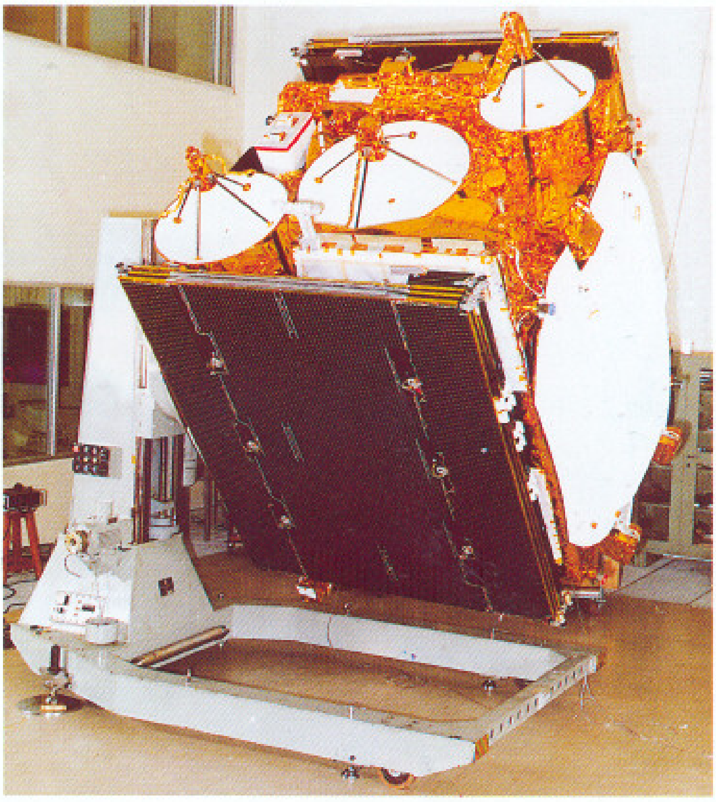
The meeting of the Working Group on Information Systems and Services (WGISS) of the international Committee for Earth Observation Satellites (CEOS) was held in Bangalore during October 21-24, 1997. During the meeting which hosted by ISRO, the working group discussed various aspects of coordinating information systems and services that space agencies could provide to the users. The meeting was attended by 26 technical experts from space agencies around the world.

Dr K Kasturirangan, Chairman, ISRO, who inaugurated the meeting, requested the working group to consider key issues like data catalogues, use of high-speed networks for procuring data, browsing and data dissemination, intranet for the CEOS and issues which are of importance to developing countries. Ms Helen Wood, Chairperson of the Working Group highlighted the tasks initiated by WGISS, including, provision of remote sensing data on CD-ROM to developing countries, definition of strategy for the working group, information locator service, etc, all of which have helped in providing advanced service to the users of earth observation data.

CEOS is an international forum of space agencies coordinating earth observation satellites, ground segment for data reception, processing, dissemination and demonstration of specific user applications. WGISS is one of the two working groups of CEOS and is charged with the responsibility for optimising benefits of earth observation satellites in mission planning, development of compatible data services, applications and policies.

The present meeting assumes significance since ISRO will be taking over the Chairmanship of CEOS in November 1997 for the year 1997-98.

Power Bus Anomaly on INSAT-2D — Becomes Inoperable



INSAT-2D

INSAT-2D, which was launched on June 4, 1997 on board the Ariane Launch vehicle from Kourou in French Guyana, has become inoperable due to a power bus anomaly. The satellite lost earth-lock on the night of October 1, 1997 but had been recovered the following morning. However, only 25 to 30 percent of rated power output was available. Three of its 23 transponders had also been switched on using the available power and the satellite was under close observation to study and analyse the performance in its degraded-power condition. The satellite had lost all its redundancy and its thermal management had become difficult. Efforts were going on to analyse and simulate the probable reasons for the anomaly and possibility of any recovery but the satellite lost earth-lock again on the night of October 4, 1997 because of the problems associated with the thermal management which, in turn, led to anomalies in the propulsion system that maintains the satellite attitude. The compounding of the problems resulting from the power loss, thermal management and the propulsion system made the recovery of the satellite impossible.

The satellite was colocated along with INSAT-2A at 74° East longitude. The services from INSAT-2D have since been transferred to the other INSAT satellites — INSAT-1D, INSAT-2A, INSAT-2B and INSAT-2C.

Award for Prof U R Rao's Book

"Space Technology for Sustainable Development" a book written by Prof U R Rao, Member, Space Commission and former Chairman of ISRO, has won the prestigious Book Award of the International Academy of Astronautics (IAA). The book is published by Tata McGrawHill Publications, Delhi. The annual Book Award, consisting of a citation and medal, was presented to Prof Rao on October 7, 1997 during the 48th International Astronautical Federation (IAF) Congress at Turin, Italy.

Accepting the award, Prof Rao stated that his close working with developing nations provided him the inspiration to undertake this work. The book deals with the relevance and application of space technology for socio-economic development of the global population three quarters of which is struggling to find their equitable and rightful place in the global village. It may be recalled that Prof U R Rao had earlier received Alan D.Emil Award for International Cooperation in 1992, and Frank G Malina Award for Space Education in 1994, both given by IAF, Paris. He is the only person to-date who has received all the three prestigious awards instituted by IAF/IAA. ◘

Indian Satellites in Operation

Sl. No.	Satellite	Launch Date	Highlights
1.	Indian National Satellite (INSAT-1D)	12.06.1990	Fourth operational multi-purpose communication and meteorology satellite procured from USA. Launched by US Delta launch vehicle.
2.	Indian National Satellite (INSAT-2A)	10.07.1992	First satellite in the second-generation Indian built INSAT-2 series. Multi-purpose satellite for telecom, TV broadcasting, meteorology & disaster warning. Has enhanced capability than INSAT-1 series. Launched by European Ariane launch vehicle.
3.	Indian National Satellite (INSAT-2B)	23.07.1993	Second satellite in INSAT-2 series. Identical to INSAT-2A. Launched by European Ariane launch vehicle.
4.	Indian National Satellite (INSAT-2C)	07.12.1995	Has additional capabilities such as mobile satellite service, business communication and television outreach beyond Indian boundaries. No meteorology payload. Launched by European launch vehicle, Ariane.
5.	Streched Rohini Satellite Series (SROSS-C2)	04.05.1994	Launched during fourth developmental flight of ASLV. Carries Gamma Ray astronomy and aeronomy payload.
6.	Indian Remote Sensing Satellite (IRS-1B)	29.08.1991	Second operational remote sensing satellite. Launched by Russian launch vehicle, Vostok.
7.	Indian Remote Sensing Satellite (IRS-1C)	28.12.1995	Carries advanced remote sensing cameras. Launched by Russian Molniya launch vehicle.
8.	Indian Remote Sensing Satellite (IRS-P3)	21.03.1996	Carries remote sensing payload and an X-ray astronomy payload. Launched by third developmental flight of PSLV.
9.	Indian Remote Sensing Satellite (IRS-1D)	29.09.1997	Identical to IRS-1C. Launched by India's PSLV.

Celebrating the 50th year of Independence. Antariksh Bhavan, Bangalore, the Headquarters of ISRO was colourfully illuminated on the night of August 15, 1997.