OCT. - DEC. '94

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

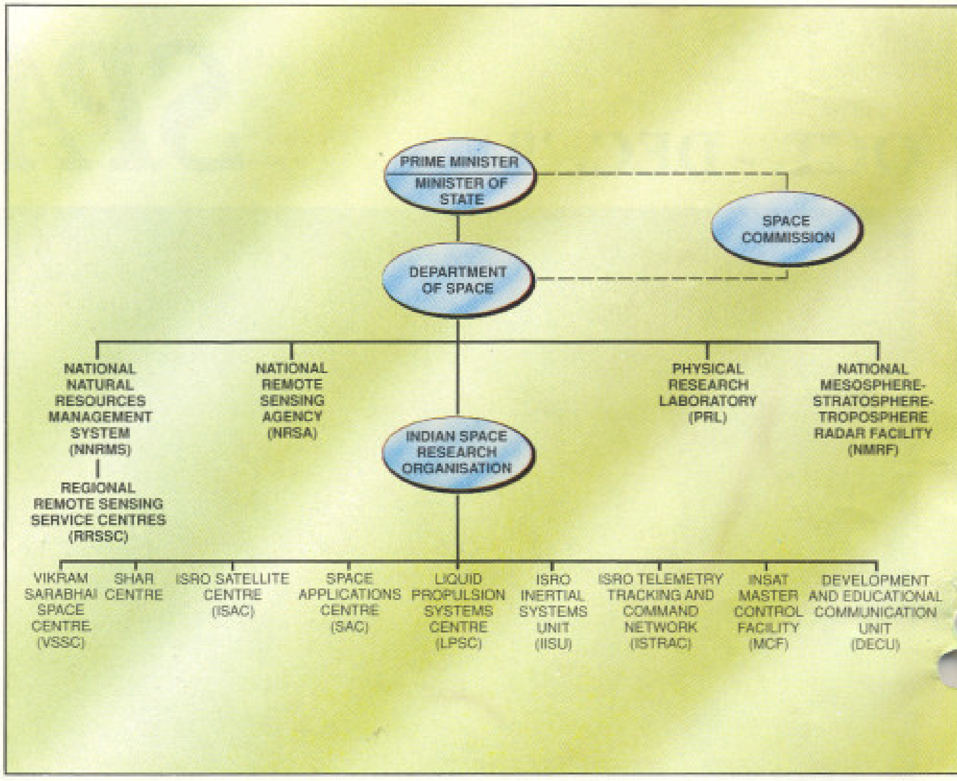
The Indian Space Programme

The setting up of the Thumba Equatorial Rocket Launching Station(TERLS) in 1963 marked the begining 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. □



FRONT COVER
PSLV-D2 ready for lift-off

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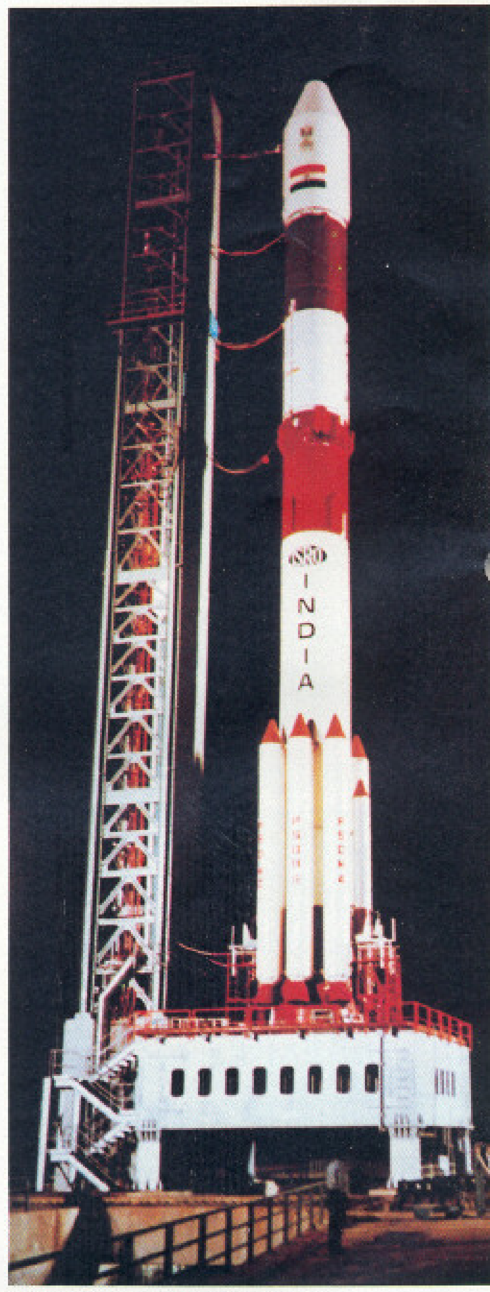
PSLV - D2

Launch Successful

A very significant milestone in the Indian space programme was crossed on October 15, 1994 with the successful launch of the Polar Satellite Launch Vehicle (PSLV), from the Sriharikota Range (SHAR) at 1035 hours IST. In this second developmental launch, PSLV-D2, the 804 kg Indian remote sensing satellite, IRS-P2, was successfully placed into a near polar sun-synchronous orbit.

PSLV-D2 took-off with the ignition of the core first stage (PS-1) and two strap-on motors and, was aided 30 seconds later, by the ignition of remaining four strap-on motors. The first set of two strap-on motors separated at 73 seconds after lift-off and the second set of strap-on motors at 90 seconds. The first stage separation and the second stage ignition occurred at 111 seconds. The heatshield was jettisoned at 154 seconds at an altitude of 117 km after the vehicle had cleared the dense atmosphere. The second stage separation and the third stage ignition occurred at 261 seconds and the third stage separated at 380 seconds as planned. At this stage, the altitude was 421 km. The last stage ignited after a long coasting at 591 seconds. The guided injection of the satellite into the precise orbit at an altitude of 820 km occurred at 1012 seconds after lift-off, with the fourth engine being terminated earlier around 988 seconds.

PSLV is a four-stage vehicle. The first and third stages use solid propellants and the second and fourth stages use liquid propellants. The first stage has a 2.8 m diameter core motor (PS-1) and six 1.0 m diameter motors (PSOMs) strapped on to the core. The core motor case is made of M250 grade Maraging steel and it has a propellant loading of 129 t. Each of the PSOM, made of 15CDV6 steel, is loaded with 9 t of solid propellant. The second stage, carries 37.5 t of liquid propellant (12.5 t of UDMH and 25 t of N_2O_4) stored in an aluminium alloy tank, 2.8 m in diameter. The third stage



PSLV-D2 on the launch pedestal

motor has a Kevlar-epoxy case and carries 7 t of solid propellant. The fourth stage has 2 t propellant for its twin 7 kN engines.

The Inertial Guidance System (IGS) in the Equipment Bay (EB) housed around the fourth stage guides the vehicle till spacecraft injection. The closed-loop guidance scheme resident in the on-board computer ensures the required accuracy on injection conditions.

The three-axis attitude stabilisation of the vehicle is achieved by autonomous control systems provided in each stage. The first stage employs Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw and two swivellable Roll Control Thrusters (RCT) along with SITVC system on the PSOMs for roll control. During a short coast after first stage burnout, the RCT engines are used for yaw and roll control and a set of four reaction control motors is used for pitch control. The second stage has Engine Gimbal Control (EGC) for pitch and yaw and hot gas Reaction Control System (RCS) for roll control. The third stage has Flex Nozzle Control (FNC) for pitch and yaw during thrust phase. The fourth stage is controlled during thrust phase by gimballing its two engines for pitch, yaw and roll. RCS is provided on the fourth stage for coast phase control in pitch, yaw and roll. This RCS also provides roll control during third stage burn phase also.

PSLV employs PCM S-band telemetry systems, S-band range and range rate system and C-band transponders for performance monitoring, tracking, range and flight safety and preliminary orbit determination.

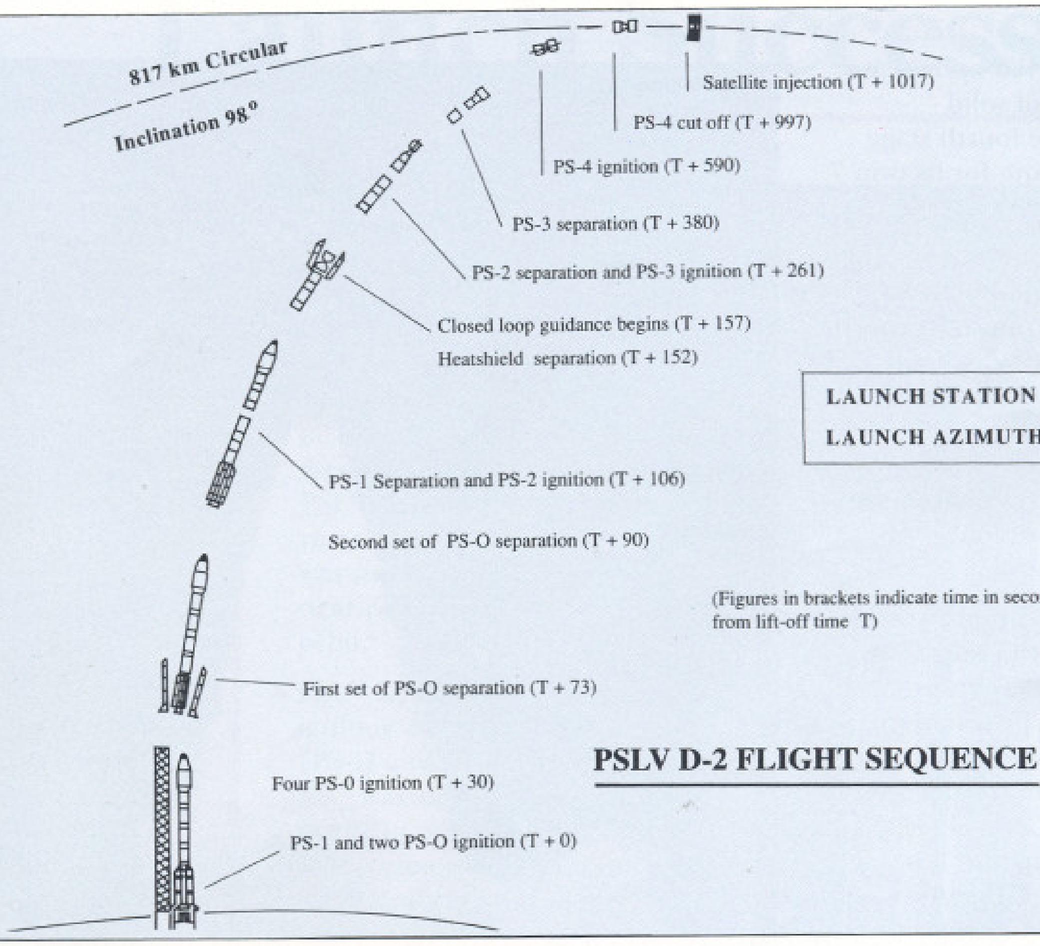

The lift-off

An Aluminium alloy heatshield of 3.2 m diameter protects the spacecraft during the ascent phase. The stage separation systems include ball and socket joint with spring thruster for strap-ons, Flexible Linear Shaped Cord (FLSC) system for first stage, Merman band for second stage and ball and lock mechanism for third stage separation system. Retro rockets are used on first and second stages to ensure safe stage separation. Ullage rockets are provided on second stage to ensure positive acceleration of the vehicle at the time of second stage ignition. Spacecraft separation is based on Merman band system.

(A separate article on state-separation system has been included in this issue of Space India).

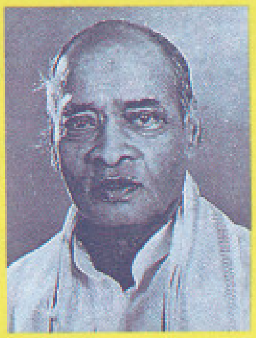
It may be recalled that the first developmental launch (PSLV-D1) which took place on September 30, 1993 could not complete its mission despite the fact that all individual hardware systems had performed well. This mission failure was later traced to an error in the implementation of on board software.

IRS-P2, the satellite launched by the PSLV-D2 is the third Indian remote sensing satellite in service designed by the ISRO Satellite Centre, Bangalore.



PSLV D-2 FLIGHT SEQUENCE

Message from Prime Minister



Immediately on being informed of the successful launch of PSLV-D2, the Prime Minister Mr P V Narasimha Rao sent the following message:

"I was very happy to learn a little while ago of the successful launch of the Polar Satellite Launch Vehicle D-II from Sriharikota by our Department of Space.

The successful launch is a matter of great pride and satisfaction for the entire nation. Not only has the PSLV been developed by indigenous technology and manpower, even the remote sensing satellite put into orbit by the launch vehicle has been manufactured indigenously.

With this launch India has crossed yet another milestone in its journey to complete self-sufficiency and technological independence in the area of space applications.

On behalf of the nation, I congratulate the Members of the Space Commission and the officials and employees of the Department of Space who have worked relentlessly and dedicated themselves to making this project a success."

Message from Minister of State (PMO)

The Minister of State (PMO) Mr Bhuvanesh Chaturvedi, who was in New York, on October 15, 1994, conveyed the following message to Chairman, ISRO on being informed of the successful launch of PSLV-D2:

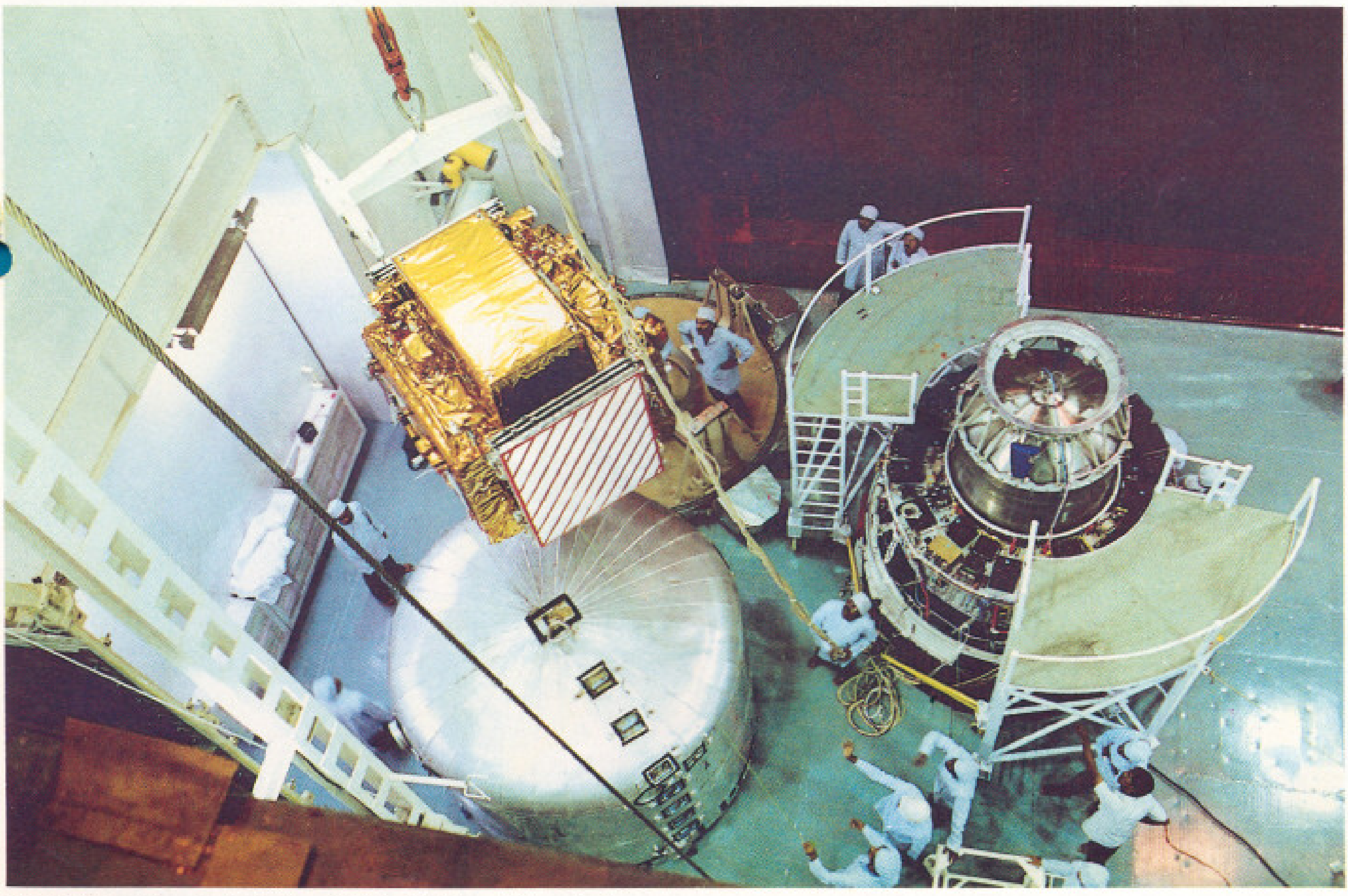
"I would like to congratulate you and all your colleagues on the successful launch of the PSLV. We are all delighted at this splendid achievement of our talented and dedicated scientists and engineers.

This event is a commendable step forward in the development of our space programme in which the entire country takes pride."

IRS-P2 carries a Linear Imaging Self Scanner (LISS-II) camera, similar to LISS-II flown on board IRS-1A and 1B. It has a spatial resolution of 32 m across track and 37 m along track. The swath is 131 km. The camera operates in four spectral bands in the visible and near IR regions. The payload was developed by the Space Applications Centre, Ahmedabad. The 804 kg spacecraft has two deployed solar panels generating 510 W of power.

IRS-P2 was declared operational on November 7, 1994 following a series of successful precise orbit manoeuvre operations. The special orbit manoeuvres carried out on the spacecraft, using the 11 Newton and 1 Newton thrusters, enabled the spacecraft to reach the

A view of the vehicle with mobile service tower in the back ground



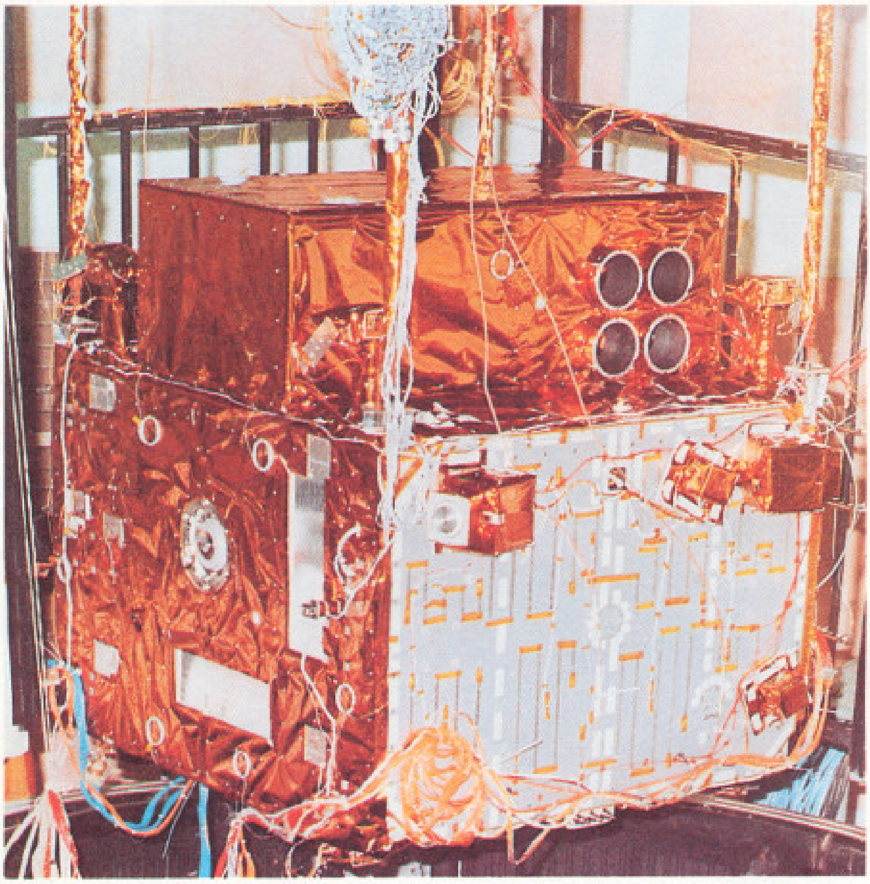
IRS-P2 being integrated with the vehicle inside the mobile service tower

A view of the Launch Complex

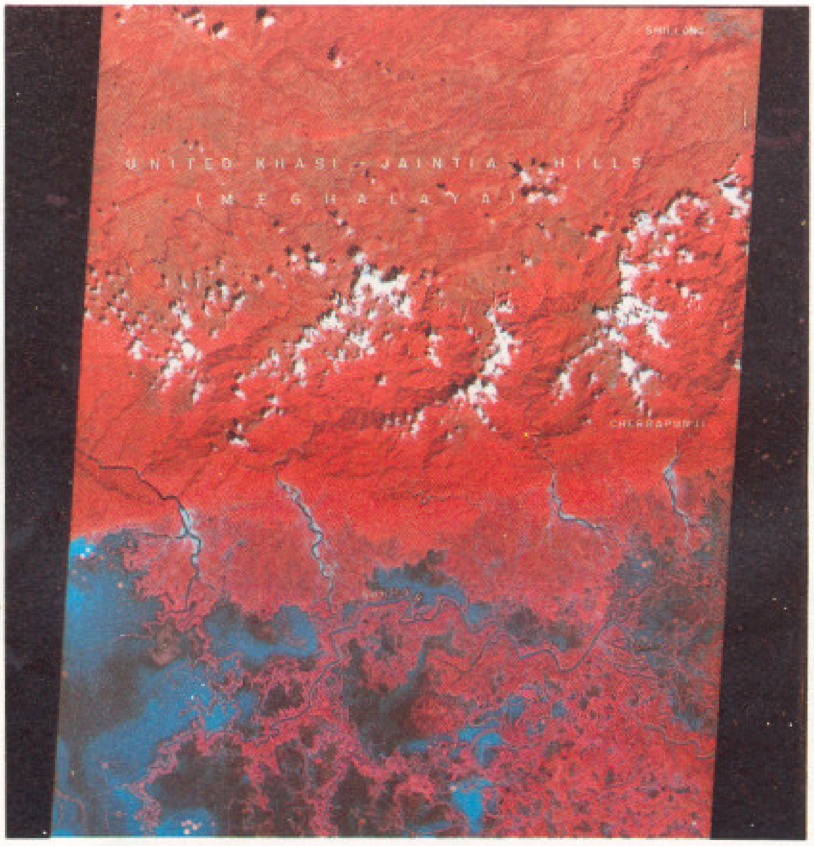
Mr G Madhavan Nair, Project Director, PSLV, (right) having a word with Prof Satish Dhawan, Member, Space Commission and former Chairman, ISRO, (second from left) before the launch

The jubilation immediately after the successful launch

Immediately after the successful launch, a function was organised at SHAR Centre during which Chairman, ISRO (third from right), some of the Space Commission Members, Directors of ISRO Centre and Project Director, PSLV, addressed a gathering. Addressing the gathering is Mr R Aravamudan, Director, ISAC



IRS-P2 (above) and one of the first few imageries received from the satellite taken over Meghalaya State (below)



sunsynchronous orbit of 817 km and attain a frozen perigee orbit. This orbit ensures that the imageries taken over various latitudes will have no significant scale variations due to orbit apsidal motion. This is the first time that such a manoeuvre has been carried out in the IRS missions. The orbit has also been adjusted to cover a well defined standard path and row referencing scheme on ground to facilitate unique identification of the geographical regions of interest and cataloguing of data products. With the completion of the above orbit manoeuvre exercises, IRS-P2 covers the whole country every 24 days with the local time of equator crossing at 10.40 a.m.

IRS-P2 is being monitored and controlled by the ISRO Telemetry, Tracking and Command Network (ISTRAC) stations at Bangalore, Lucknow and Mauritius with the Spacecraft Control Centre at Bangalore. TTC support is also being provided by the station at Bearslake near Moscow and, during the initial phases of the mission, by the TTC stations at SHAR, Thiruvananthapuram and Weilheim, Germany. The IRS-P2 data reception and processing is carried out by the National Remote Sensing Agency, Hyderabad.

Having already established the indigenous capability, through the INSAT and IRS satellites, to provide uninterrupted space services in the areas of telecommunication, TV broadcasting, meteorology, disaster warning and natural resources survey and management, ISRO has now demonstrated through the successful launch of PSLV-D2 that it also has the capability to place IRS class of satellites in the polar orbit. Since a number of technologies and systems already proven in the PSLV feed directly into ISRO's Geosynchronous Satellite Launch Vehicle (GSLV) programme, the success of PSLV-D2 can be said to have brought the country to the threshold of self-reliance even in launching the INSAT class of satellites. □

Stage Separation Systems for Launch Vehicles

A view of the main laboratory for testing aerospace mechanisms at VSSC

In multistage launch vehicles, each stage has its own propellant tankage (or motor case) and controls. When the propellant of a stage is expanded, the dead weight of that stage, consisting of empty tanks, engine and controls, is no longer useful and hence needs to be separated from the rest of the vehicle and jettisoned. By dropping off these spent stages, the net mass that is to be accelerated further is made smaller. This is how higher payloads and velocities are achieved by using multiple stages. It should, however, be noted that there is no appreciable gain in payload by using a large number of stages; the number of stages in an operational vehicle usually lies between three to five. For example, the Polar Satellite Launch Vehicle (PSLV) has four stages while the Geostationary Satellite Launch Vehicle (GSLV) has only three.

Evidently, the stage separation systems are very crucial to the success of any launch vehicle mission. Quite a few of the launch vehicle mission failures the world over have been attributed to the malfunctioning of the staging mechanisms. The story in ISRO has been different in that no mission failure has ever been explicitly or solely due to the malfunctioning of any staging mechanism.

Some of the factors which need detailed consideration while designing a separation system are flight loads, stiffness and dynamic characteristics, clearance between separating bodies, allowable shock levels, damage or contamination by debris, fault tolerance, control transition zone.

A separation system generally consists of three basic elements; an actuation to trigger the event, a release system to physically separate the bodies and a separation-impulse system to impart the needed separation velocity.

Varieties of actuation, release and separation-impulse systems are employed in the launch vehicles developed in ISRO. For example, actuation may be achieved through a simple medium like cold compressed gas or through electrically initiated pyro devices like bolt cutters, explosive nuts and pyro-thrusters. Similarly, a release mechanism could be either mechanical or pyrosystem. Examples of the mechanical type are: Merman bands and ball block separation systems. Flexible linear shaped charge and zipcord, on the other hand, belong to the pyro category.

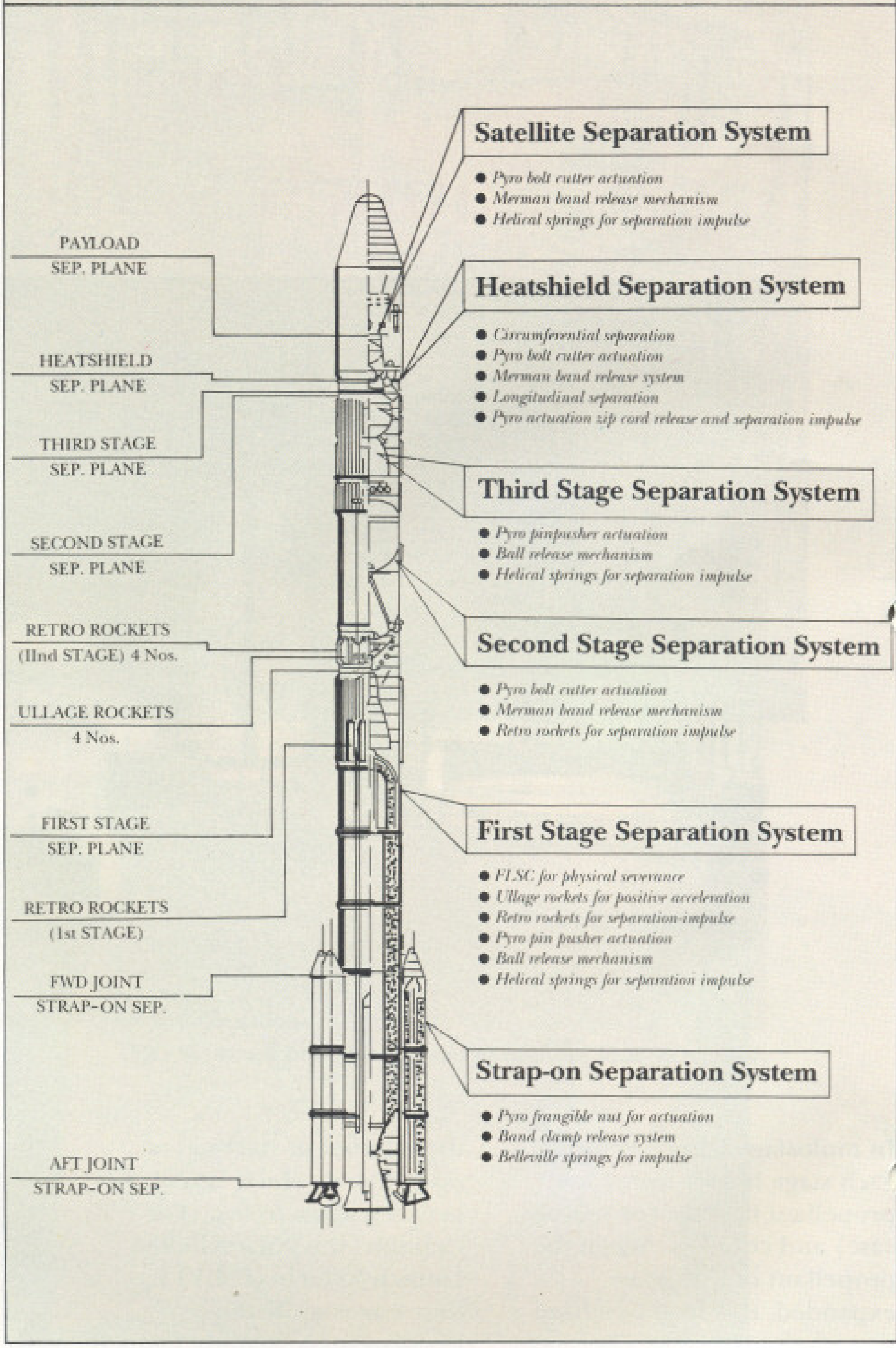
The separation-impulse can also be delivered in a variety of ways, depending on the type of bodies to be separated, as shown below:

Satellite separation : Mechanical springs

Heatshiled separation : Zipcord
First stage separation (PSLV) : Metro rockets
First stage separation (GSLV): Hot gas vented interstage

Since flight conditions can never be fully simulated by ground qualification tests, extensive theoretical modeling and analysis becomes indispensable. One, therefore, needs advanced computational facilities because closed form solutions are often not available. Finite element structural analysis to study static and dynamic responses, six degree-of-freedom rigid body dynamic analysis to study separation processes and Computational Fluid Dynamic (CFD) to understand hot gas interaction, are combined judiciously to assess and predict the flight performance of separate system. For example, the breathing motion of heatshield (due to its flexibility) superimposed on rigid body mode helps avoid boundary collision in the PSLV and GSLV.

Separation Systems for PSLV



Separation of lower stages in a launch vehicle become all the more complex because of aerodynamics. Therefore, wind tunnel time march studies and scale model tests to validate and reinforce analytical results become necessary. Once the uncertainties in tail-off thrust, starting transients, thrust analysis is geometric clearances are known, Monte Carlo analysis is carried out to obtain improved understanding of the separation process.

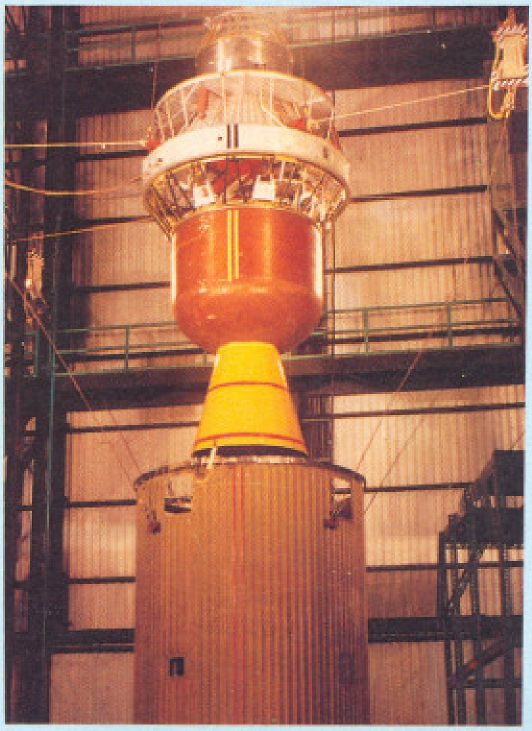
In-depth FMECA (Failure Mode Evaluation and Criticality Analysis) is done to investigate the effects of component failure on system performance and mission. FMECA is also used to assess whether modification are required to improve redundancy and fault tolerance in the system.

Pyro for Separation

Pyro devices are important elements in stage separation systems. With relatively large amounts of energy packed into small volumes, these devices are ideal for rapid action. In pyro bolt cutters and frangible nuts, explosive energy is used to severe the components and actuate a release device like merman band (heatshield) or band clamp (strap-on). The flexible linear shaped charge (FLSC), which produces a high speed metallic jet caused by the collapse of the shaped charge (Munroe effect) can cut metallic rings. It is used for circumferential separation where structural integrity and high joint rigidity are required during the flight phase as in the case of lower stages of a launch vehicle. FLSC is not generally used for upper stages because of the likely adverse effects of relatively high separation shock on critical payload components. In the zipcord system, the gases of explosion expand in a piston-cylinder assembly to shear the rivets and then push the separated fairings apart. Thus the zip cord combines two of the three functions necessary in a separation system: the release and the separation-impulse mechanisms.

Being one-shot-type of devices, pyros have to be absolutely reliable because their function is crucial to any mission. Exhaustive and rigorous testing of these devices under a variety of environmental conditions, therefore, becomes an essential part of the qualification programme.

Separation of the first spent stage is effected by severing the interstage (upper) between the first and second stage by flexible linear shaped cord. Eight retro-rockets on the interstage (lower) decelerate the spent stage. Four ullage rockets on interstage (upper) accelerate the continuing stage momentarily. Ullage rockets are mounted in pairs on A-frames attached to the interstage by ball-lock mechanism. Once their function is over, the ullage rockets are separated and jettisoned (Picture right) by first releasing the ball-lock by a pyro pin-pusher and then pushing them apart by spring thrusters.



A multiple stage separation system comprising clamp band for the second stage and ball release mechanism for the third stage, is the first of its kind. The clamp band system consists of a series of V-clamps hooked on the interstage to be separated, and a pair of high strength-metallic bands tightened over them by means of a pair of tension bolts. For separation, these bolts are severed by pyro-actuated bolt cutters. A smooth 3.6 m pull out is achieved by the retro rockets mounted on the aft end of the second stage.

The third stage separation system is based on a ball release mechanism. This system acts as passive joint till the second stage separation. It uses a series of balls to lock the interface rings. The ball lock is released by actuating four pyro thrusters. Helical compression rings positioned in between the stages provide the relative velocity required for separation.

The satellite interface ring and payload adopter are held together by a series of V-shaped blocks hooked on the interface flanges and held in position by a pair of high strength bands preloaded by high strength bolts. Pyro-actuated cutters are used to severe the bolts thus separating the satellite. Compression springs provide the needed separation velocity.

The PSLV Heatshield and Its Separation System

The primary purpose of the heatshield is to provide a smooth aerodynamic front to the rocket. It also protects the payload (i.e. the satellite), equipment bay and the fourth stage of the vehicle from aerodynamic heating during the rocket ascent through denser regions of the atmosphere. Once the rocket clears the critical region, the heatshield is separated from the rocket.

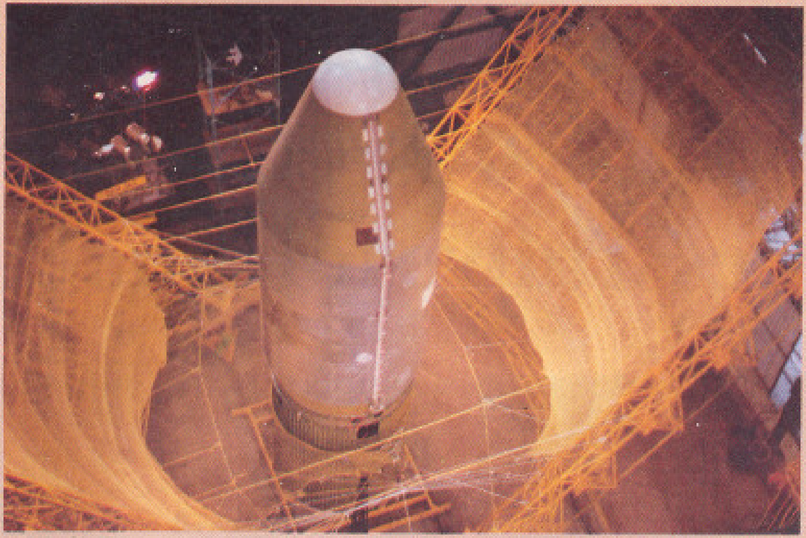
The heatshield is designed to withstand the flight loads likely to be experienced by the vehicle during its ascent. The heatshield is fabricated in two longitudinal halves, so that its separation from the vehicle (after clearing the critical atmospheric regime) is easily achieved.

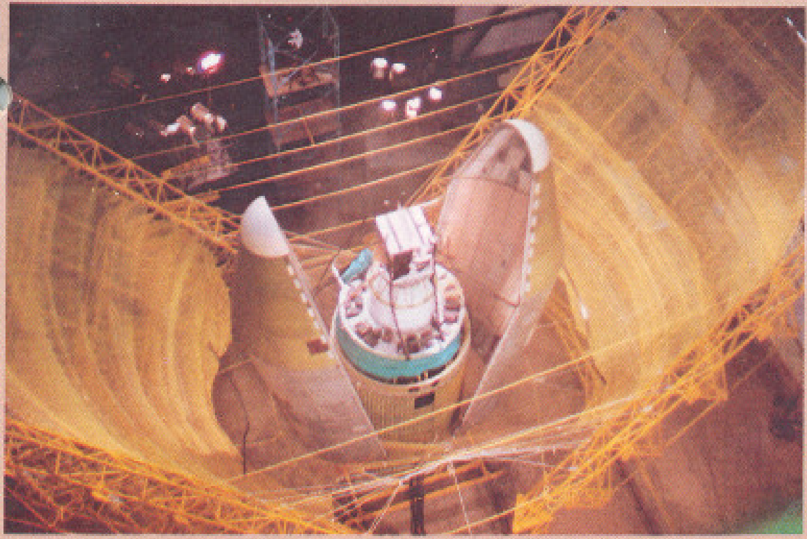
The heatshield comprises three parts: (i) a top conical structure including a hemispherical cap, (ii) a middle cylindrical section, and (iii) a rear boat-tail portion. While the conical structure is circumferential stiffened, the cylindrical part is integrally stiffened by means of isogrid construction. In the latter, thick flat plates are machined to isogrid shape, rolled into cylindrical shells and joined by rivetting. The boat-tail is a semi-monocoque structure in which the skin is stiffened with stringers.

All these are assembled in two halves, the edge beams of which provide the necessary interface for incorporating the zip-cord separation system. The boat-tail contains the Merman band separation system which also interfaces with interstage between third and fourth stages. The heatshield is made of high strength aluminium alloys.

The Merman band and zipcord separation concept is first demonstrated in the boat-tail test using a trunctuated heatshield. Since testing the full heatshield by simulating flight environment is impractical, an elaborate scheme of ground testing is carried out with the test hardware well instrumented to measure shock, vibration and rigid body motions.

The various qualification tests, including functional tests, carried out for the PSLV heatshield are structural tests, vibration tests, sinusoidal and random, separation tests, five boat-tail of three full scale, acoustic test followed by separation test, band tension test, thermal protection system qualification tests and acoustic protection system qualification tests.

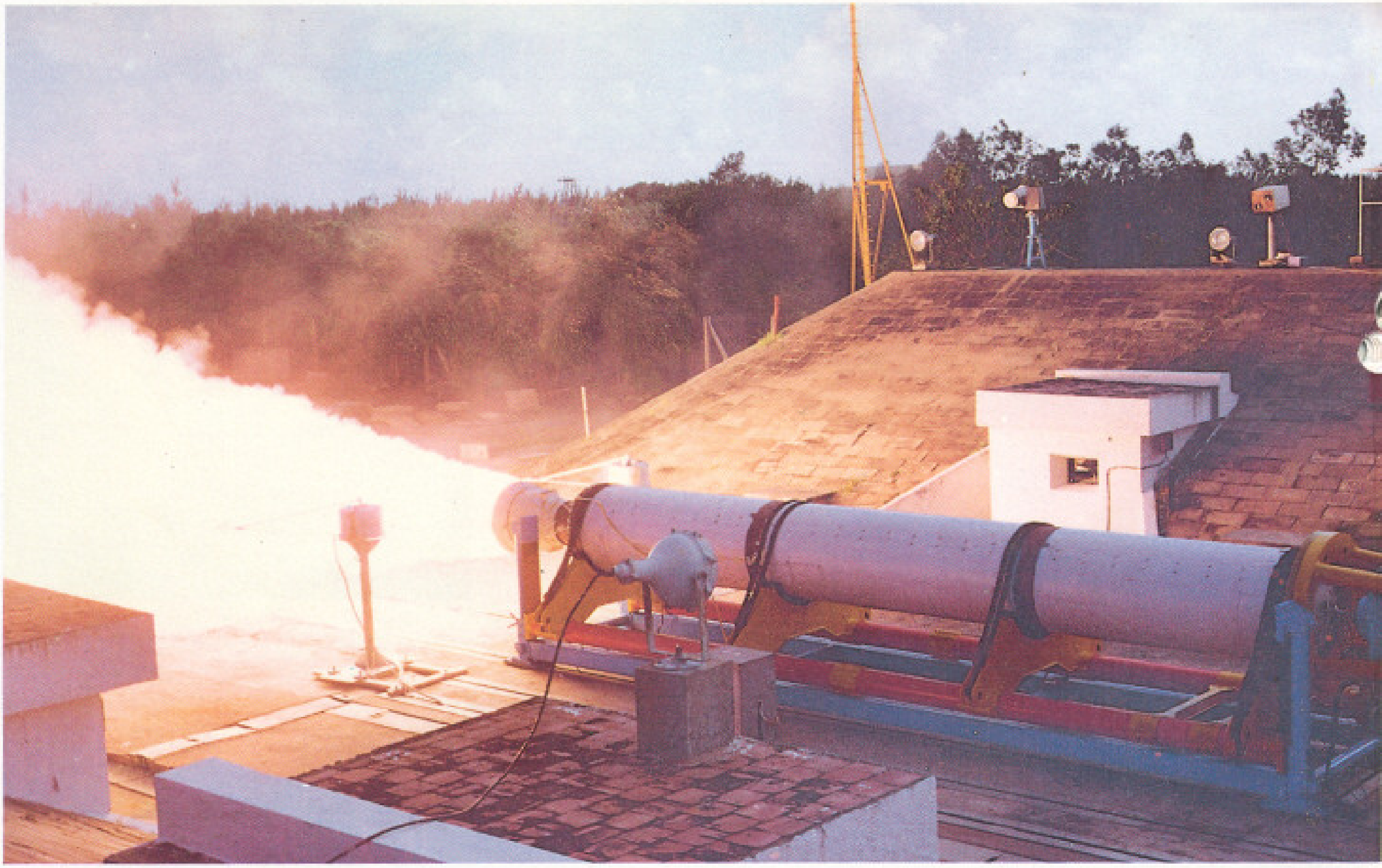




To the extent possible these systems are tested on ground to validate the separation concept, to demonstrate system performance and to ensure conformity to flight specifications. New concepts, of course, require appropriate developmental tests. Qualification process includes functional tests and environmental tests which instill confidence in the designer regarding the performance of the system under the worst case flight conditions which include: static loads, vibration and shock loads, acoustic loads, temperature, vacuum levels, humidity, weightlessness, etc. Wherever possible, full scale functional tests are also performed. Acceptance tests are conducted on flight hardware to check for workmanship defects.

The process of qualifying a separation system like that of the heatshield of PSLV is fairly complex and involves a large number of tests □

Monolithic Solid Propellant Rocket Motor Tested Successfully



Static test of the motor

ISRO has successfully tested a monolithic version of the one-metre diameter, 10 t solid propellant motor. The ground static test of the motor, using HTPB propellant, was conducted on November 17, 1994 at SHAR Centre, Sriharikota. The test results show that the performance of the motor is close to that of the segmented version which has been used in all the ISRO's launch vehicles so far — SLV-3, ASLV and PSLV.

The one-metre diameter solid propellant motor of the segmented version was developed by the Vikram Sarabhai Space Centre, Thiruvananthapuram, for the first stage of SLV-3 and for the first stage and strap-ons in ASLV. PSLV, which had its first successful launch on October 15, 1994, uses six strap-on motors of this class. The successful testing of the monolithic version of the motor is a significant step in the weight optimisation efforts for the PSLV strap-on motors. □

The 15th Asian Conference on Remote Sensing held in Bangalore

The 15th Asian Conference on Remote Sensing (ACRS) was held during November 17-23, 1994, at the National Science Seminar Complex, Bangalore. The Conference was inaugurated by His Excellency, the Governor of Karnataka, Mr Khursheed Alam Khan. Dr Pranab Kumar Mukherjee, Deputy Chairman, Planning Commission and Union Minister of Commerce was the Chief Guest. Prof U R Rao, Member, Space Commission and Chairman, National Organising Committee of the Conference presided over the function. Dr Shunji Murai, General Secretary, ACRS, presented a report on the Asian Association on Remote Sensing (AARS). Dr K Kasturirangan, Chairman, Space Commission/ ISRO and Executive Chairman of the 15th ACRS welcomed the delegates.

His Excellency, the Governor of Karnataka Mr. Khursheed Alam Khan inaugurating the ACRS by lighting the lamp

Organised every year by the AARS which has members mainly from the developing countries of the Asia Pacific Region and the UN Bodies, the conference provides an opportunity for the Members to discuss developments in Remote Sensing and its applications specially to the Region. AARS, for the last 14 years, has effectively proposed the development of remote sensing technology and its application in the Region.

The 15th conference was hosted by the Indian Space Research Organisation (ISRO), with the support of other Central Government/State Government Agencies, Academic Institutions and Industries.

The Bangalore Conference had the following main objectives:

- To discuss Asian problems in remote sensing;
- To exchange academic, application and technical information;
- To promote regional co-operation amongst the member countries; and
- To promote operational applications of remote sensing and Geographical Information Systems (GIS).

To coincide with the 15th ACRS, a UN-ESCAP Regional Seminar on Integrated Application of Remote Sensing and Geographical Information System for Land and Water Resources was also held from November 16 to November 19, 1994.

It is to be noted that the countries of the Asia Pacific Region, most of them with tropical climate, face many common problems such as the ever increasing population and, consequently, increase in the demand for food, shelter and other necessities. This has led to several environmental and ecological problems. The emerging space-based remote sensing technology has provided some hope by making available valuable information necessary for the monitoring and optimum management of the fast depleting natural resources. Space-based remote sensing can provide data for application in several areas of development like agriculture, forestry, land resources, water

Dr. Shunji Murai presenting the report on AARS

A Plenary session chaired by Prof U R Rao (second from right)

One of the stalls at the exhibition organised in connection with ACRS

resources, coastal mapping, environmental monitoring, mineral prospecting, ocean resource development and management of disasters such as floods and drought.

India has made good progress in the development and application of space-based remote sensing technology. The indigenous remote sensing satellites, IRS-1A and IRS-1B launched in March 1988 and August 1991 respectively, have become the mainstay of the National Natural Resources Management System. India has also designed and built the Polar Satellite Launch Vehicle (PSLV), which had its first successful flight on October 15, 1994 when it placed the IRS-P2 satellite in the intended orbit. Thus, India has now three satellites providing remote sensing services to the nation. India is also developing more advanced satellites, IRS-1C and IRS-1D, with the former scheduled for launch in 1995. The applications of the data obtained using the IRS satellites have now spread to almost every facet of the country's development. Examples of IRS data utilisation include those for pre-harvest acreage and production estimation of all major Indian crops like wheat, rice and sorghum, estimation of production of cotton, oil seeds, mulberry, etc, soil mapping, grassland mapping, forest survey, landuse/land cover mapping, locating underground water resources, estimation of snow cover and snow melt/run-off, monitoring water level in reservoirs, environment monitoring, etc. IRS data has also been extensively used for flood mapping and identifying flood-risk zones and for forecasting drought conditions, identifying ocean zones of great fishing potential, etc.

More importantly, IRS data is being extensively used for the unique Integrated Mission for Sustainable Development (IMSD) which has been launched in 157 districts of India. IMSD is aimed at generating locale-specific prescriptions for development at microlevel using integrated analysis of the thematic maps generated using the IRS, meteorological and socio-economic data. Already, recommendations based on the pilot studies under IMSD are being implemented in six districts of the country with highly encouraging results.

India has consciously encouraged the use of satellite-based remote sensing technology by setting up Regional Remote Sensing Service Centres (RRSSCs) in Kharagpur, Nagpur, Jodhpur, Dehra Dun and Bangalore. Several States have also set up their own Remote Sensing Application Centres. Courses on Remote Sensing in school and university curricula have also been introduced.

It is no exaggeration to say that India is in the forefront of both developing and industrially advanced countries, in exploiting the potential of remote sensing data for development.

Thus, since the holding of the last ACRS in India, in Hyderabad in 1985, the country has achieved substantial progress in this field. It is therefore significant that the 15th Asian Conference on Remote Sensing was again held here. It was a good opportunity for the Asian countries to hear the Indian delegates describe their experience in exploiting the remote sensing technology for national development. The Conference is expected to promote cooperative ventures in the field among the countries of this region, which represents the largest landmass as well as the main concentration of the population; a region that is destined to determine the progress of humanity as a whole!

ISRO/ANTRIX stall at the exhibition

The ACRS at Bangalore was attended by 320 delegates including 83 foreign delegates. The countries represented at the conference included: Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Iran, Japan, Jordan, Kazakhistan, Kuwait, Malaysia, Mongolia, Myanmar, Nepal, Singapore, Sri Lanka, Thailand and Vietnam, Canada, France, The Netherlands, Switzerland, the USA and the UK.

The Conference had two Plenary, two commercial (Technical Information), thirteen technical (oral presentation) and three poster sessions. Altogether 67 papers were presented during the technical sessions and 28 papers were displayed in the poster sessions. An exhibition organised during the Conference saw participation by 14 companies and organisations from all over the world.

It was heartening to note that there is an increase in remote sensing agencies and institutions in Asian Region, which promote not only operational applications but education and training as well. Quite appropriately, regional cooperation, especially with respect to generation of data-base for Asia, education, training and public domain software for educational purpose was rightly emphasised by the participants.

The General Conference of the AARS, Chaired by Prof U R Rao, decided Thailand, Sri Lanka and Malaysia would be the venues for 1995, 1996 and 1997 conferences respectively.

Agreement Between India and Russia on Space Co-operation

An Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes was concluded between the Indian Space Research Organisation (ISRO) and the Russian Space Agency (RSA) on December 23, 1994. The agreement was signed by Dr K Kasturirangan, Chairman, ISRO, and Dr Yuri Koptev, Director-General, RSA, in the presence of Prime Minister of India, Mr P V Narasimha Rao and the Russian Prime Minister, Mr Viktor S Chernomydrin.

Over the last three decades, cooperation between India and the erstwhile USSR has been quite fruitful; launches of the Indian satellites, Aryabhata, Bhaskara-I and Bhaskara-II were carried out under the cooperative agreement with USSR. The launches of IRS-1A and IRS-1B satellites on board the Russian 'Vostok' launch vehicles were carried out on a commercial and cooperative basis. Purchase of cryogenic stages for ISRO's GSLV launch vehicle and launch of ISRO's IRS-1C satellite on the Russian Molniya launch vehicle in 1995 are the important on-going programmes between India and Russia.

During the visit of Prime Minister, Mr Narasimha Rao, to Russia in June 1994, an umbrella agreement had been signed which identified ISRO and RSA as the executive organisations to implement cooperative space projects. The present Agreement between ISRO and RSA is to provide a legal and organisational basis for specific cooperative projects to be taken up between the two agencies. The Agreement envisages cooperation in several areas such as space science, use of space equipment and ground-based facilities, space meteorology, monitoring of the earth's environment from outer space, materials processing in space, space medicine, remote sensing of the earth, space communications and, carrying out research activities on manned and unmanned spacecraft and joint data analysis. □

Mapping from Space

Sponsored jointly by the Indian National Cartographic Association (INCA) and the Department of Space the 14th International Congress "Mapping from Space – Cartographic Challenges" was held at ISRO Satellite Centre, Bangalore, during November 28-30, 1994. The Congress was aimed at bringing together professionals specialising in generation of the mapping data, data use, space system design and applications on to a common platform.

The main challenge faced by the cartographic community is to update the maps and release them to planners on time. The conventional methods of using the photogrammetric techniques with aerial photographs and ground surveys, currently followed by some agencies are very slow and expensive. Though currently India has done exceptionally well in bringing out 1:50,000 scale maps countrywide and in preparing 1:25,000 scale maps for 40 per cent of the landmass, there is scope for improving the speed of updating and promptness in releasing them to the users.

The availability of high resolution space imagery and sophisticated computer-based processing and analysis techniques, has led to quick generation and prompt updation of maps. The worldwide demand now is for digital maps and very high resolution digital images. With the United States desensitising space imagery upto one metre

Prof M G K Menon, Member of Parliament, inaugurating the INCA Congress (above) and Dr K Kasturirangan, Chairman, ISRO inaugurating the exhibition (below)

Dr Kasturirangan delivering the presidential address

resolution, quite a few companies have already come forward to supply space imagery of this type to the civilians. From such imagery, it is possible to extract topographic features with resolution and reliability required for the creation and updation of 1:25,000 scale maps.

In India, with the availability of Indian Remote Sensing Satellites, IRS-1A and IRS-1B, and the recently launched IRS-P2, many users have now fine tuned their map production technique with a suitable mix of information derived from space and conventional approaches. A number of countrywide mapping exercises, on appropriate scales, have already been carried out by many agencies in association with the Department of Space. They include forest maps, wasteland maps, landuse/landcover maps, geological maps, coastal maps, etc, on scales upto 1:50,000. The next generation Indian Remote Sensing Satellites, IRS-1C and 1D, the former scheduled for launch in 1995, will provide imagery with resolutions better than 10 metre. These satellites will also provide stereoscopic imagery necessary for deriving height information. The emergence of computer-based spatial data analysis system, the Geographical Information System (GIS), has given a great fillip to the exploitation of data in the digital form. The GIS accepts inputs in digital form from existing maps, remote sensing imageries and conventional spatial and non-spatial (statistical) information. The GIS is capable not only of storing such information in different layers but in manipulation of different data sets to produce a variety of maps/statistical information of interest to specific users.

Thus, map users in India could expect to have, sooner than later, updated data for maps with a short turn-around time. The INCA Congress at Bangalore addressed several aspects relating to these new developments in cartography that are of immediate interest to the users.

The Congress was inaugurated by Prof M G K Menon, Member of Parliament, while Dr K Kasturirangan, Chairman, Space Commission/ISRO, presided over the inaugural function. Prof G Konecny of the University of Hannover, Germany, delivered the keynote address. Prof U R Rao, Member, Space Commission, delivered the first Todermul Memorial Lecture on November 29, 1994. The Congress was attended by about 300 delegates. □

A view of the exhibition

Training Courses at the Indian Institute of Remote Sensing, Dehra Dun

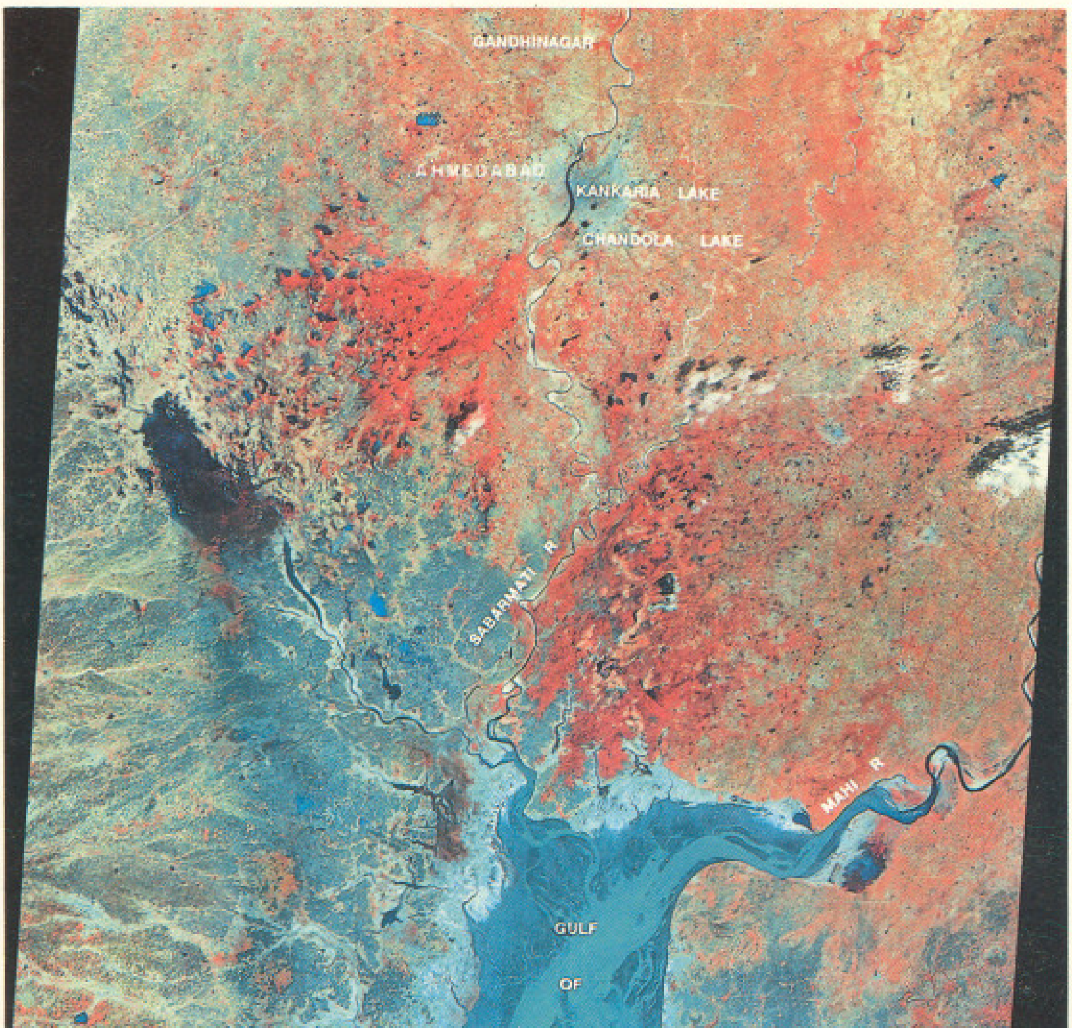
The Indian Institute of Remote Sensing (IIRS) at Dehra Dun is a premier institute for training of scientific and technical personnel in the application of Remote Sensing techniques. IIRS is functioning under the National Remote Sensing Agency (NRSA) of the Department of Space. The institute has been conducting regular training courses since 1966 and more than 3,000 scientists/engineers including 182 foreign nationals have been trained. The institute has revised and upgraded its curricula in the light of the advances in satellite remote sensing, computer applications and to meet the specific needs of the National Natural Resources Management System (NNRMS) in India.

The training programmes proposed to be conducted during 1995 are as follows:

	Ten-Month Post-graduate Diploma Courses	From	To
1.	Geology & Geomorphology & Hydrology	March 6, 1995	January 5, 1996
2.	Urban & Regional Planning (Human Settlement Analysis)	March 6, 1995	January 1, 1996
3.	Coastal Processes & Marine Resources	July 17, 1995	May 17, 1996
4.	Agriculture & Soils	July 17, 1995	May 17, 1996
5.	Forestry & Ecology	July 17, 1995	May 17, 1996
6.	Water Resources	July 17, 1995	May 17, 1996
	Three-Month Courses		
7.	Basic Photogrammetry & Remote Sensing	March 6, 1995	June 2, 1995
8.	Basic Photogrammetry & Remote Sensing	July 17, 1995	October 13,1995
9.	Basic Technology & concepts in Human Settlement Analysis	March 6, 1995	June 2, 1995
10.	Land Information System	June 5, 1995	September 1, 1995
	Eight-Weeks Course		
11.	Remote Sensing Course	October 30, 1995	December 22, 1995
12.	Orientation Courses on Remote Sensing Application to:		
	a) Geology & Geomorphology	June 12, 1995	June 23, 1995
	b) Water Resources	June 12, 1995	June 23, 1995
	c) Urban & Regional Planning	June 12, 1995	June 23, 1995
	d) Agriculture & Soils	June 12, 1995	June 23, 1995
	e) Forestry & Ecology	June 12, 1995	June 23, 1995
	f) Coastal Processes & Marine Resources	June 12, 1995	June 23, 1995
	Four-Day Courses		
13.	Overview Course for Decision Makers	May 23, 1995	May 26, 1995
14.	Workshop in Remote Sensing Technology for town planning	November 7, 1995	November 11, 1995
	Photography Courses		
	Aerial & Satellite Photo Processing	April 4, 1995	April 28, 1995
	Colour Photography	October 11, 1995	October 29, 1995
	Special Course in Photography	May 22, 1995	June 9, 1995
	Special Course in Photography	October 3, 1995	October 27, 1995

Further details can be obtained from:

The Dean,
Indian Institute of Remote Sensing
No. 4 Kalidas Road, Dehra Dun - 248 001, India
Fax : 0091-135-24583 Telephone : 0091-135-24583
Grams: Remotipi, Dehra Dun (India)



One of the first few imageries transmitted by IRS-P2. The imagery covers parts of Gujarat