JAN-JUNE '96

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

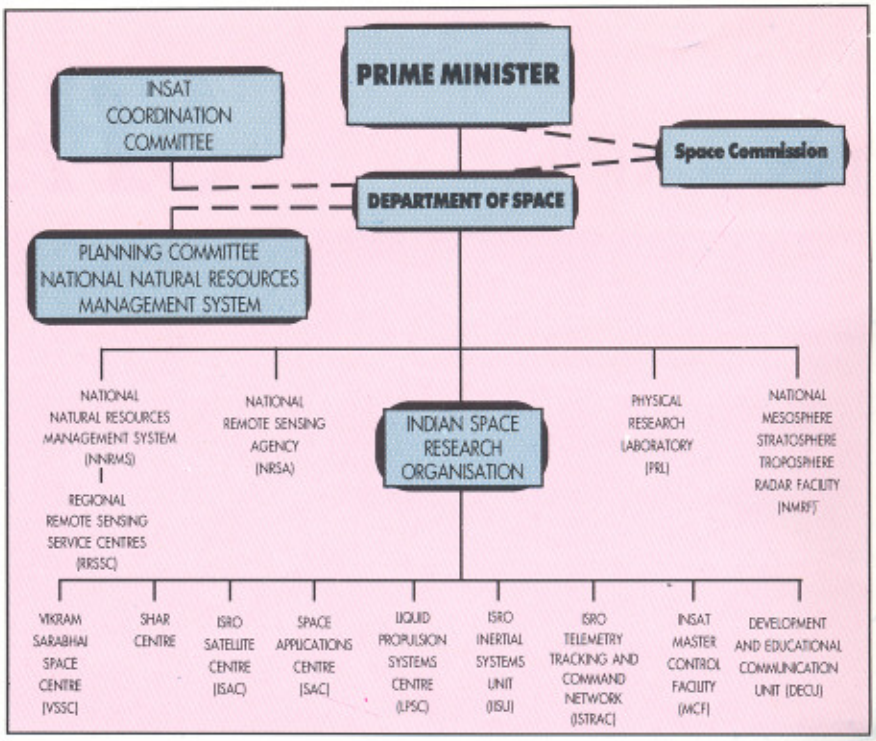
The Indian Space Programme

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.

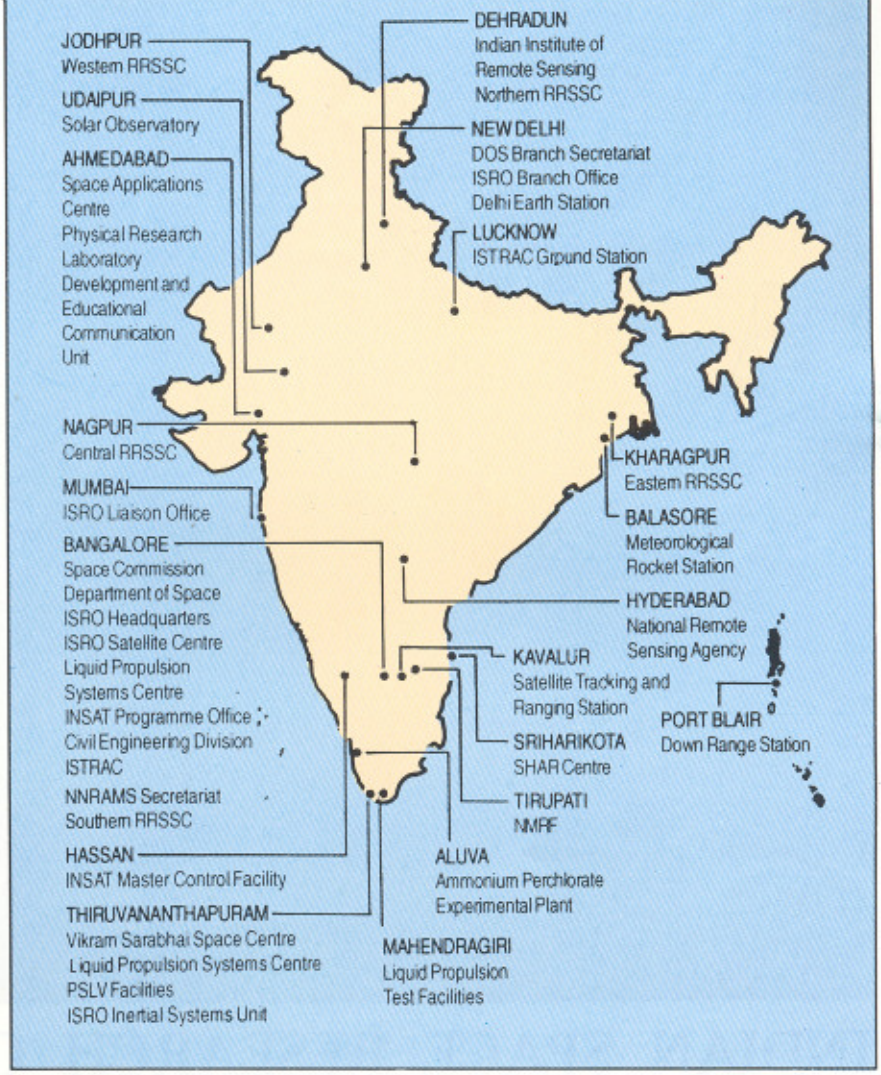
The Indian Space Programme is directed towards the goal of self-reliant use of space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological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



Space Centres and Units in India



FRONT COVER
PSLV-D3 lift-off

CONTENTS

EDITORS
S. Krishnamurthy
Manoranjan Rao

EDITORIAL ASSISTANCE
S.K. Dutta

PRODUCTION ASSISTANCE
B. Chandrasekhar

JAN-JUNE '96

SPACE India is published quarterly by the Indian Space Research Organisation for limited circulation.

Editorial/Circulation Office:
Publications & Public Relations Unit
ISRO Headquarters, Antariksh Bhavan, New BEL Road,
Bangalore - 560 094 India.

Printed at M/s. S.N. Process Pvt. Ltd., Bangalore, India

PSLV-D3 Launch Successful

PSLV-D3 on launch pad

The third developmental flight of Polar Satellite Launch Vehicle, PSLV-D3, was successfully conducted this morning (March 21, 1996) from Sriharikota Range (SHAR). PSLV-D3, carrying a 922 kg Indian Remote Sensing satellite, IRS-P3, lifted off at 10.22 hrs. IST and 17 minutes later successfully placed the satellite into a near polar sun-synchronous 817 km orbit. Shortly after the separation from the launch vehicle, an on-board sequencer initiated the deployment of solar panels of the satellite.

PSLV-D3 took off with the ignition of core first stage (PS-1) and two strap-on motors. The remaining four strap-on motors were ignited 31 seconds later. The first set of two strap-on motors separated at 73.4 seconds and the second set of strap-on motors separated at 90.4 seconds. The first stage separation and the second stage ignition occurred at 111 seconds after lift-off. The heatshield was jettisoned at an altitude of 117 km when the launch vehicle had cleared the dense part of the atmosphere. The second stage separation and the third stage ignition occurred at 267 seconds and the third stage separated at 489 seconds from lift-off as per plan. The last stage ignited after a long

coasting at 611 seconds. The fourth stage cut-off occurred at 1029 seconds and IRS-P3 was injected into orbit 1043 seconds after lift-off at an altitude of about 820 km.

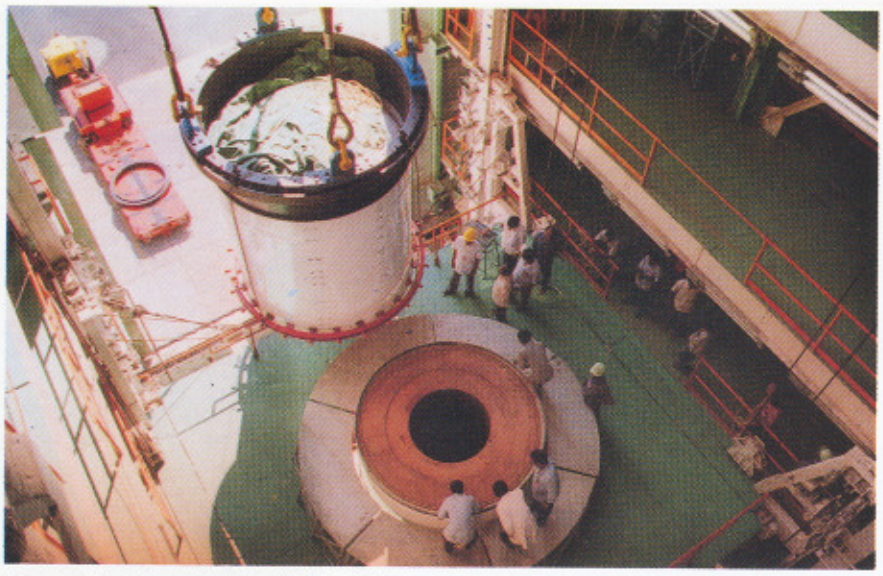
The closed-loop guidance system came into effect at about 157 seconds after lift-off and guided the vehicle till the injection of the satellite into orbit. The spacecraft was placed in orbit in a three-axis stabilised mode.

With a lift-off weight of about 283 tonne, the 44 metre tall PSLV has four stages. The first stage, carries 129 tonnes of propellant and measures 2.8 m in diameter. The motor case is made of maraging steel which is indigenously produced. The booster develops a maximum thrust of 4,500 kN. The first stage thrust is augmented by six strap-on motors, two of which are ignited on the ground.

All solid propellant motors use indigenously produced Hydroxyl Terminated Poly-butadiene (HTPB) fuel and Ammonium Perchlorate oxidiser.

The second stage employs indigenously manufactured Vikas engine and carries 37.5 tonne of liquid propellant – Unsymmetrical Dimethyl 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.



One of the five segments of PSLV first stage motor being assembled

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 which is of isogrid construction, besides providing an aerodynamically smooth front to the vehicle, 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 used for PSLV is the strap-down version with guidance system resident in the equipment bay. It guides the vehicle till the injection of spacecraft into orbit.

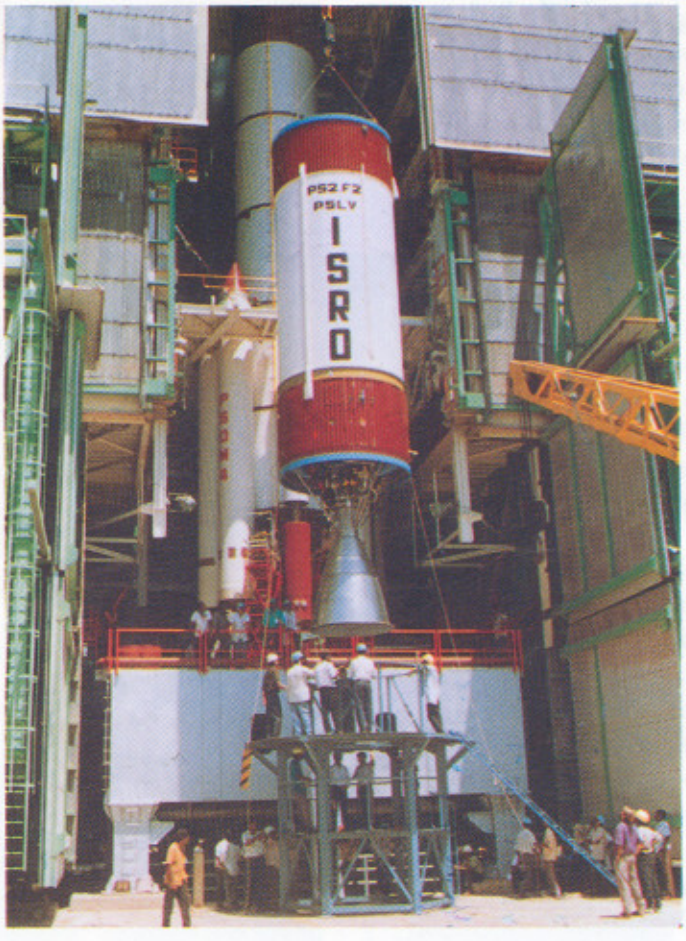
The main on-board instrumentation packages used for telemetry, tracking and command are: PCM/S-band telemetry systems, S-band Range and Range rate transponders and C-band transponders, besides a host of power and signal condition- ing packages. PSLV employs a large number of stage auxiliary systems for stage separation, heatshield separation and jettisoning, etc.

With the Vikram Sarabhai Space Centre in Thiruvananthapuram acting as the lead centre, 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. The ISRO Inertial Systems Unit, Thiruvananthapuram, has

developed the navigation systems for PSLV. The ISRO Telemetry, Tracking and Command Network (ISTRAC) is responsible for the telemetry and tracking support to PSLV mission through its stations at Sriharikota, Mauritius and Thiruvananthapuram.

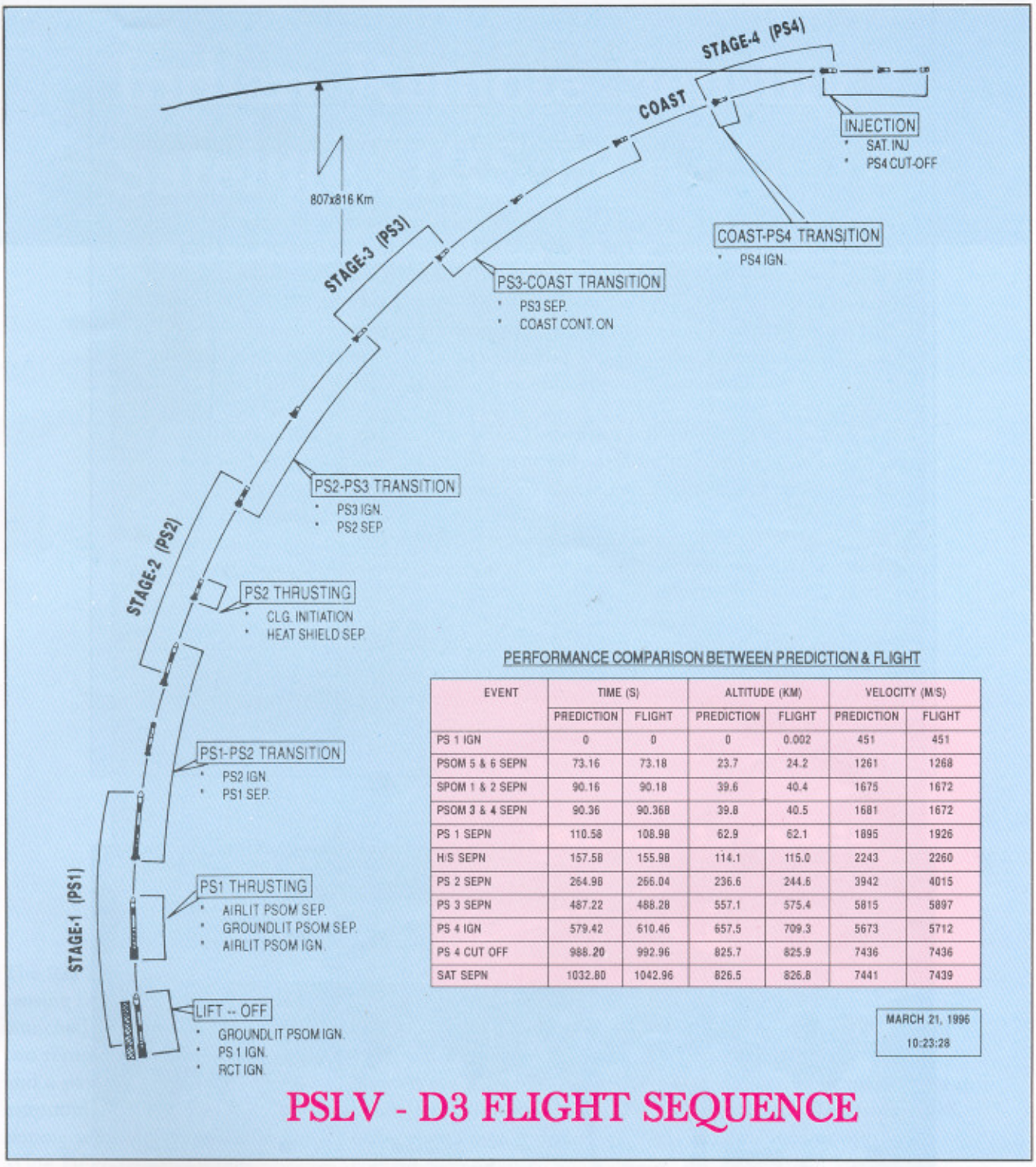
Well over 150 industries, both in the public and private sectors, have been involved in the fabrication of a variety of hardware: light alloy structures for interstages, motor cases, electronic packages, heatshield, precision coherent radars, etc. Even in the field of chemicals and materials, the industries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

PSLV-D3 is the second consecutive successful flight and the last of the developmental series of PSLV. The second developmental launch of PSLV (PSLV-D2) had been successfully conducted on October 15, 1994 when IRS-P2 satellite was placed in a polar orbit; the satellite is functioning well since then. Based on a detailed analysis of PSLV-D2 flight data, several improvements have been carried out in PSLV-D3 such as inclusion of wind-biased trajectory to reduce effective load on the vehicle during its ascent through atmosphere and reduction in insulation and nozzle mass of third stage by about 74 kg. The equipment bay weight has



Liquid Propulsion second stage of PSLV being lifted on to the mobile service tower.

Third and fourth stage composite assembly



PERFORMANCE COMPARISON BETWEEN PREDICTION & FLIGHT

EVENT	TIME (S)		ALTITUDE (KM)		VELOCITY (M/S)	
	PREDICTION	FLIGHT	PREDICTION	FLIGHT	PREDICTION	FLIGHT
PS 1 IGN	0	0	0	0.002	451	451
PSOM 5 & 6 SEPN	73.16	73.18	23.7	24.2	1261	1268
SPOM 1 & 2 SEPN	90.16	90.18	39.6	40.4	1675	1672
PSOM 3 & 4 SEPN	90.36	90.368	39.8	40.5	1681	1672
PS 1 SEPN	110.58	108.98	62.9	62.1	1895	1926
H/S SEPN	157.58	155.98	114.1	115.0	2243	2260
PS 2 SEPN	264.98	266.04	236.6	244.6	3942	4015
PS 3 SEPN	487.22	488.28	557.1	575.4	5815	5897
PS 4 IGN	579.42	610.46	657.5	709.3	5673	5712
PS 4 CUT OFF	988.20	992.96	825.7	825.9	7436	7436
SAT SEPN	1032.80	1042.96	826.5	826.8	7441	7439

MARCH 21, 1996
10:23:28

PSLV - D3 FLIGHT SEQUENCE

also been reduced by about 25 kg. Improvements have been carried out in the fourth stage auto-pilot and PS-3/PS-4 coast phase control to improve the system performance.

Three more launches of PSLV – PSLV-C1, PSLV-C2 and PSLV-C3 have already been planned. PSLV-C1, scheduled for launch in about 18 months, will carry a remote sensing satellite, IRS-P4 incorporating an ocean colour monitor.

That, PSLV-D3 has proved the repeatability of performance of the various systems of PSLV and validated all modifications carried out on the vehicle, signifies an important milestone towards operationalising PSLV for launching India's remote sensing satellites and to realise India's Geosynchronous Satellite Launch Vehicle, GSLV, which employs a majority of the systems developed and flight proven through PSLV.

MESSAGES

On learning about the successful launch of PSLV-D3 on March 21, 1996, Prime Minister Mr P V Narasimha Rao sent the following message:

"I have just received the news of the successful launching of the Polar Satellite Launch Vehicle D-3 from Sriharikota. This is the second consecutive success of the Polar Satellite Launch Vehicle programme, with the PSLV-D2 having been successfully launched earlier in 1994. The fact that the launch vehicle and the IRS-P3 satellite on board the vehicle have not only been developed indigenously, but are also technological improvements over the previous launch is testimony to the continuing success of the country's space programme and a matter of pride for all Indians.

On behalf of the nation and on my own behalf I congratulate all the scientists, engineers and staff of the Department of Space for their dedication, hard work and professionalism in making this mission a success."

In a message to Dr K Kasturirangan, Chairman, ISRO/Secretary, DOS, Mr Bhuvnesh Chaturvedi, Minister of State (In-charge of Space), sent the following message on March 21, 1996:

"I am very happy to learn that PSLV-D3 has been successfully launched today to place the IRS-P3 spacecraft in its orbit. The entire nation is proud of this achievement. I congratulate you and all your team members on this brilliant achievement that reaffirms our capability in both rocketry and satellite technology." □

Prime Minister Mr P V Narasimha Rao with Chairman, ISRO, Dr. K Kasturirangan (on his right) with other senior scientists / engineers who played a keyrole in the PSLV-D3/IRS-P3 mission when they met the Prime Minister on March 23, 1996.

Indian Remote Sensing Satellite, IRS-P3

IRS-P3 in Orbit
— An artist's concept

The 922 kg Indian remote sensing satellite, IRS-P3, launched by PSLV-D3, has two remote sensing payloads and a payload for X-ray astronomy. One of the remote sensing payloads is a Wide Field Sensor, (WiFS). The second remote sensing payload is a Modular Opto-electronic Scanner (MOS) of the German space agency, DLR. The X-ray astronomy payload is used to study time variability and spectral characteristics of cosmic X-ray sources and detection of transient X-ray sources. The satellite also carries a C-band transponder for calibration of ground radars.

The WiFS payload of IRS-P3 is similar to that of IRS-1C (launched on December 28, 1995) but with an additional Short Wave Infra-Red (SWIR) band. This additional band, being sensitive to moisture content in vegetation, provides additional data for crop condition assessment. Also, this band has applications like snow and cloud cover differentiation, snow-melt run-off studies, flood damage assessment and geology.

MOS has eighteen spectral bands. Data from MOS is primarily for use in ocean related studies in narrow spectral bands, including chlorophyll mapping for biomass estimation, coastal water discrimination, sediment transport and ocean dynamics. Data from MOS, in conjunction with WiFS data, is useful for land applications like vegetation index monitoring, biomass and desertification studies, atmospheric studies like aerosol/cloud analysis, optical turbidity, cloud and snow discrimination and water vapour content. Thus, the combination of WiFS and MOS payloads will provide vital inputs for land, ocean and atmosphere related applications. Considerable

Western part of India as seen by IRS-P3 WiFS camera

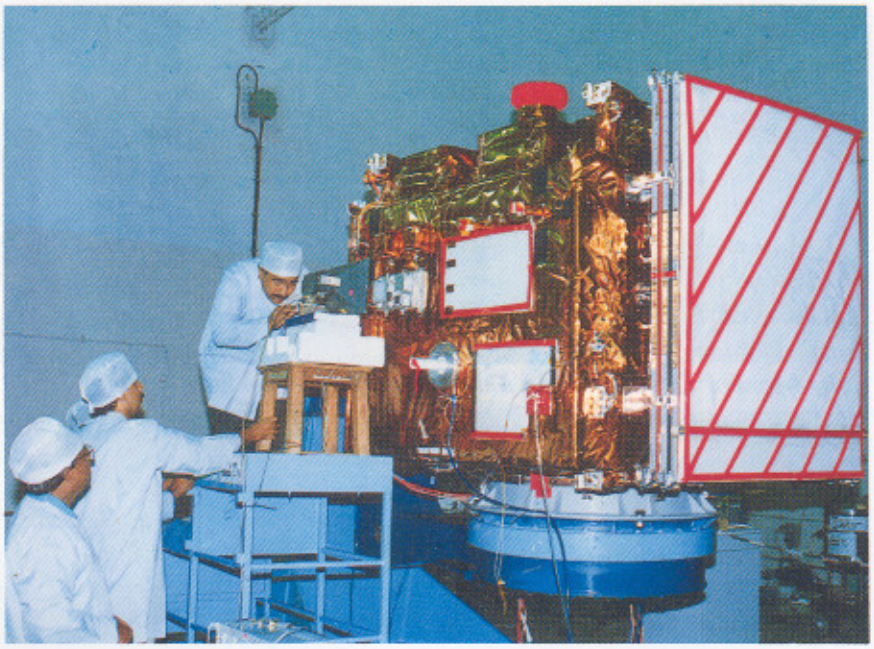
interests have been shown by a number of countries to receive data from this payload in view of its uniqueness; and perhaps for the first time, data will be available in very narrow spectral bands which is of great significance in understanding earth's geosphere and biosphere.

After its injection into orbit and automatic deployment of the two solar panels, IRS-P3 was put in a three-axis stabilised mode during its third orbit. The satellite orbit has since been fine tuned with a few short orbit trim manoeuvres to make it circular. No inclination corrections were required.

The Wide Field Sensors (WiFS) was successfully switched on at 1010 hrs. IST during its 15th orbit on March 22, 1996 by commanding from the Spacecraft Control Centre of ISRO Telemetry, Tracking and Command Network (ISTRAC), Bangalore. The satellite covered the North-Eastern region of India during this orbit. The Modular Opto-Electronic Scanner (MOS) was successfully switched on March 23, 1996 during the 29th orbit of the satellite. The payload data, is being received and processed at both NRSA, Hyderabad station and DLR station at New Strelitz near Berlin, Germany.

IRS-P3 was designed and built at the ISRO Satellite Centre, Bangalore. The Wide Field Sensor was designed and developed by Space Applications Centre, Ahmedabad. The reaction wheel, solar array drive assembly, gyros and pyro electronics were designed and developed by ISRO Inertial Systems Unit, Thiruvananthapuram. Ni-Cd cells and the C-band transponder were supplied

by the Vikram Sarabhai Space Centre, Thiruvananthapuram. The reaction control system was supplied by Liquid Propulsion Systems Centre, Bangalore. The X-ray astronomy payload was built by the Tata Institute of Fundamental Research, Mumbai. The ISRO Telemetry, Tracking and Command Network is monitoring and controlling the satellite through its network of ground stations.



Alignment checks on IRS-P3

IRS-P3 Salient Features

Mass	:	922 kg
Orbit	:	817 km polar sunsynchronous with equatorial crossing at 1030 hrs. (descending node)
Solar panels	:	9.6 sq. m. area, deployable sun tracking solar arrays generating 817 W, One 21 Ah Ni-Cd battery and one 24 Ah Ni-Cd battery.
Attitude & orbit control	:	3-axis stabilised using conical scanning earth sensors, sun sensors, star sensors and dynamically tuned gyros (DTGs), four reaction wheels, magnetic torquers and reaction control system (1 Newton thrusters and 11 Newton monopropellant hydrazine thrusters)

Wide Field Sensors (WiFS)

Spectral bands:

band-3	:	0.62-0.68 microns
band-4	:	0.77-0.86 microns
band-5	:	1.55-1.70 microns
Ground resolution	:	182 x 188 m (red and near infra-red); 246 x 188m (shortwave infra-red)
Swath	:	810 km

Modular Opto-electronic Scanner (MOS)

	MOS-A	MOS-B	MOS-C
Ground resolution(m)	1569x1395	523x523	523x644
No. of spectral bands	4	13	1
Spectral range (nm)	755-768	408-1010	1500-1700
Swath (km)	195	200	192

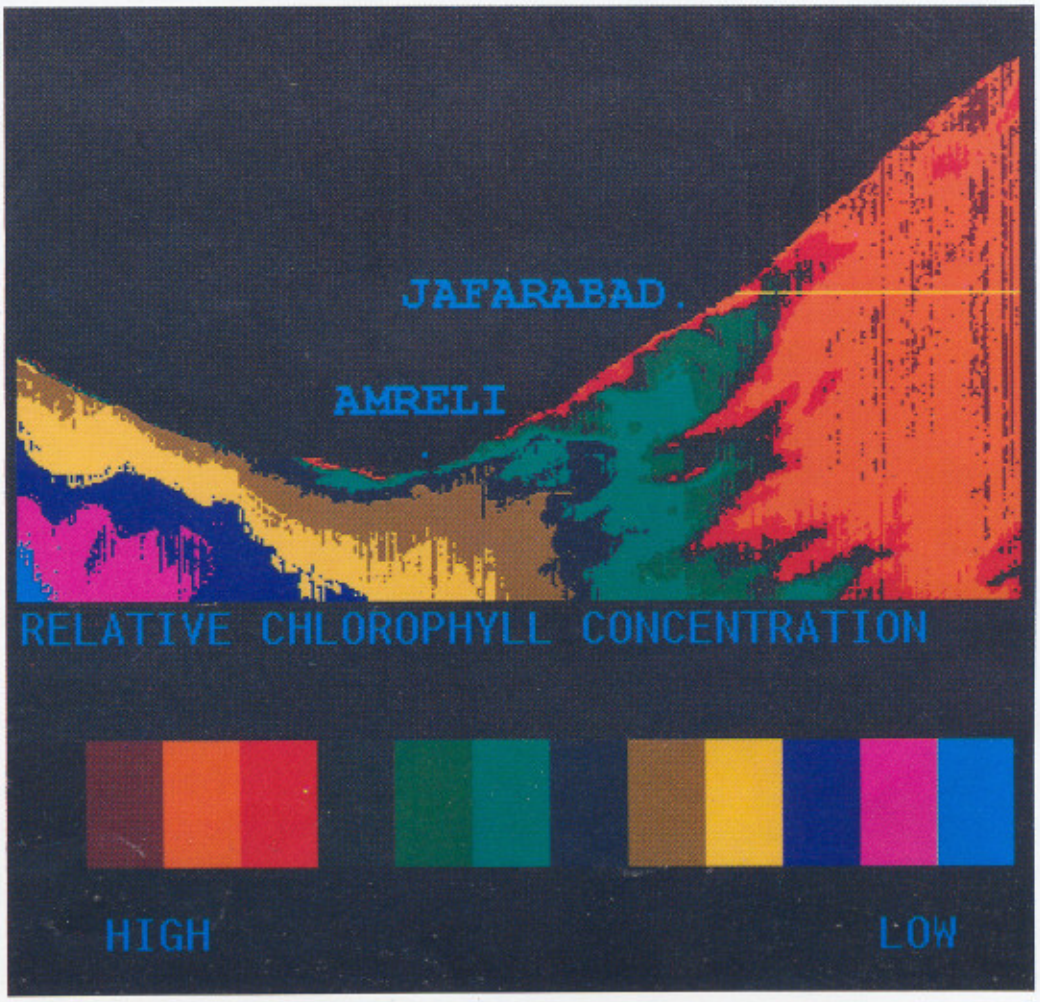
X-ray Payload

Three Pointed Proportional Counters (PPC)
Energy range : 2-20 keV
X-ray Sky Monitor (XSM)
Energy range : 2-8 keV

X-Ray Astronomy Payload

The X-Ray Astronomy payload on board IRS-P3 was designed and developed jointly by the Tata Institute of Fundamental Research, Mumbai and ISRO Satellite Centre, Bangalore. The primary objective of this payload is to obtain data to understand the high-energy astrophysical processes taking place in binary stars with a neutron star or a black-hole as the X-ray source by looking at variations in intensity and spectral characteristics of X-ray sources. This is achieved by studying X-ray pulsations and the light curves of X-ray pulsars and other types of X-ray emitting sources. The payload consists of three collimated multi-layer Pointed-mode Proportional Counters (PPCs) with an effective area of about 1200 sq cm and an X-ray Sky Monitor (XSM) based on the principle of a pin-hole camera. The pointed mode PPCs will be used to study intensity variations of X-ray sources in the stellar pointing mode while the XSM is aimed at detecting new transient sources and monitoring the intensity of known bright sources.

All the four detectors were switched on and tested during last week of April 1996. A binary star, known as Cygnus X-1, in which X-ray source is believed to be a black-hole, has been studied with the X-ray instrument during May 1-10, 1996. The X-ray star was detected unambiguously and analysis of data for studying rapid variability and quasi-periodic variations is in progress. The X-ray instrument will again be pointed towards other X-ray objects to study the periodic and irregular changes in the X-ray brightness of exotic objects like neutron stars, black-holes, etc. These investigations are expected to provide interesting astrophysical results on a phenomenon known as 'mass accretion' in which a neutron star or a black-hole in a binary pair attracts another from the visible comparison star. □



Relative chlorophyll concentration (off South Gujarat coast) derived from IRS-P3 MOS data

Integrated Mission for Sustainable Development - Progress in North-Eastern States

Integrated Mission for Sustainable Development (IMSD) aims at generating specific action plans for integrating natural resources information generated using satellite data in conjunction with other conventional and socio-economic data to arrive at locale-specific plans for sustainable development. The scope includes assessment of the natural resources potential of a region and their spatial variability in terms of geology, hydrogeomorphology, mineral resources, soils, surface and ground water resources, landuse/land cover, climatic variations, demographics and social infrastructure resources.

A review of the implementation of Integrated Mission for Sustainable Development (IMSD) in North-Eastern (NE) States indicates that the mission is making good progress.

In the NE States, today the timber producing slopes can hardly support any agriculture due to the practice of shifting cultivation known as 'Jhuming' where in the farmers after a few crops burn the fields and shift their agricultural operations to a new area. A recent study by the Regional Remote Sensing Service Centre (RRSSC), Kharagpur, has indicated that the agriculture produce from Jhuming is no more economical. The major objectives of IMSD in NE States, therefore, are to find solutions to the problems of Jhuming and to stop consequent environmental degradation as well as to combat floods in parts of Brahmaputra valley.

In Mizoram, Tuipui river watershed, located on the eastern part of Aizwal district, with an area of 940 sq km is one of the first watersheds selected under IMSD studies. The watershed is characterised by hilly terrain with very steep slopes. Jhuming is still the most prominent agricultural practice in this region which has resulted in dwindling

forest. Different layers of data have now been collected for this watershed by RRSSC, Kharagpur and National Remote Sensing Agency (NRSA), Hyderabad in cooperation with the Department of Science and Technology of Mizoram. Based on the data collected, an integrated action plan for the watershed has been generated. Two more watersheds, Lunglei and Chimtuipui districts are also being taken up for generating the action plan by the Department of Science and Technology which has the trained manpower for taking up this task.

In Manipur, Imphal and Nambul watersheds, comprising an area of 1087 sq km, have been selected as the study area. Thematic maps of drainage and surface water bodies have already been prepared. Transport and settlement mapping of watershed has also been carried out. Slope maps and landuse and land cover mapping and pre-field interpretation have been made. The State Remote Sensing Centre of the Department of Science and Technology, Manipur, is carrying out the work.

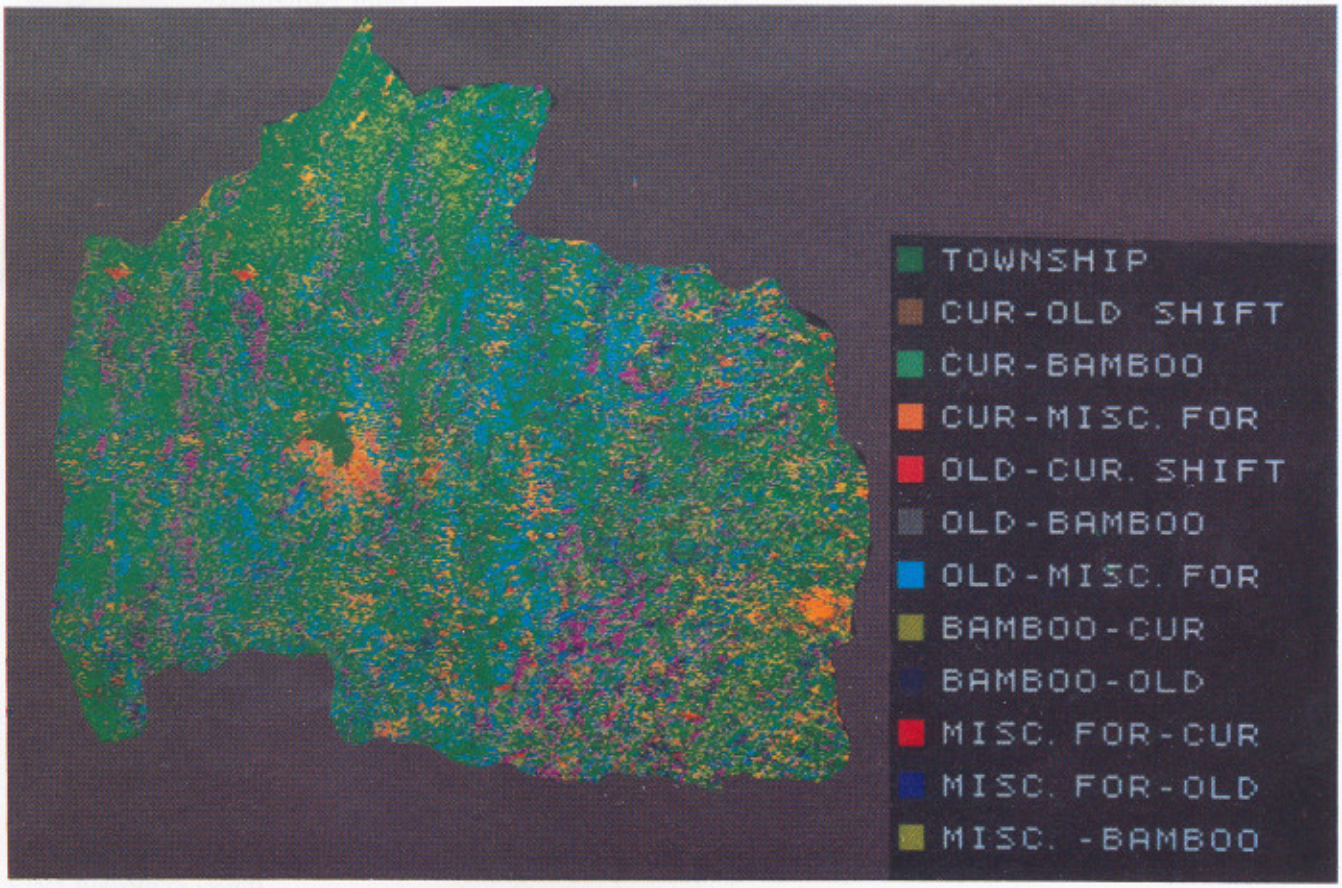
In Assam, two watersheds, Puthimary and Amri, located in Kamroop and Karbi Anglong districts respectively, have been initially selected for generating action plans under IMSD. Survey of India toposheets, watershed maps, village maps and socio-economic data have already been collected. The soil mapping is in progress. The Assam Remote Sensing Applications Centre is in-charge of the project.

Sikkim is a small hilly State in the eastern Himalaya, bounded by the vast Tibetian plateau in the north, Bhutan in the east, Darjeeling in south and Nepal in west. The entire north district of Sikkim has been selected for IMSD study. Satellite data interpretation has been carried out for the district with a few field checks to understand the area and the existing cultural and other practices of the people. Preliminary landuse and land cover maps have been prepared. Maps of surface waterbody, drainage, slope,

Imagery showing landuse/land cover in North District, Sikkim

transport network, etc, have been generated for the study area and socio-economic data is now being collected. Data related to geology and soil is also being collected for integrating with the other information for generating the action plans. The thrust given under IMSD in Sikkim includes mapping of land-slide affected areas, habitat mapping in the national parks and biosphere resources and study of forest, alphine zone, glacier and snow line migration. In Tripura, the west district comprising five blocks – Mandai, Jairania, Bishalgarh, Dukli and Takajala, have been selected for the IMSD study. While surface water, transportation and slope maps have been prepared, landuse and hydrogeomorphology maps are under preparation. Soil mapping is also being carried out. Socio-economic data has been collected at block level by the Tripura State Centre for remote sensing. In Nagaland, Dhansiri watershed, comprising about 1875 sq km in Kohima district, has been selected. Drainage, slope, transport maps have already been completed and soil maps generated by IIRS, Dehradun. Landuse and land cover maps and hydro geomorphology maps are being generated by RRSSC of Kharagpur.

The IMSD has thus begun to make a headway and with constant and determined efforts it is expected to improve the socio-economic conditions in this area in a couple of years. □



Change detection in Aizwal area of Mizoram between 1989 and 1993

National Space Science Symposium - 1996

The ninth National Space Science Symposium (NSSS-1996) was held at Osmania University, Hyderabad, during February 6-10, 1996. The symposium was inaugurated by His Excellency Mr Krishna Kant, Governor of Andhra Pradesh. NSSS-96 covered several fields of space science including: cosmic rays, high energy astronomy & astrophysics; planetary exploration; magnetosphere and interplanetary medium; solar terrestrial relationship; science of satellite communication; ionosphere and thermosphere; middle atmosphere; space-based meteorology and tropospheric system; environment, geosphere-biosphere interactions and climatic changes; oceanography and air-sea interactions; materials in space; microgravity and space biology and origin of life.

About 400 papers were received for the symposium of which 250 were selected for presentation. Ten plenary talks were given during February 6-7, which were followed by three special sessions on space data for earth system science, use of remote sensing satellite data in the studies of geosphere-biosphere interactions and astronomy from space.

In all, 15 parallel sessions and poster presentations were conducted during the symposium. A panel discussion was held on space science teachings in universities which was a special attraction. A workshop on Indian Solar Terrestrial Energy Programme (I-STEP) was also organised as part of the symposium on February 5, 1996 in which about 100 scientists participated and made recommendations for the research programme for 1996-2000 under the I-STEP. While Dr K Kasturirangan, Chairman, ISRO, gave the key-note address, Dr Harsh K Gupta, Director, National Geophysical Research Institute (NGRI), Hyderabad, gave a popular talk on earth-quakes in India with special reference to Lattur earth-quake. □

His Excellency Mr Krishna Kant, Governor of Andhra Pradesh inaugurating NSSS-1996 by lighting the lamp. Dr K Kasturirangan, Chairman, ISRO, Shri Lalith Mathur, Incharge Vice-Chancellor, Osmania University and Prof B Lokanadhan, Convener, LOC (left to right) are also seen

Delegates to the symposium

IRS-1C and IRS-P3 Data Products

The National Remote Sensing Agency Data Centre (NDC), Hyderabad, has already started supplying data products from IRS-1C since June 1, 1996. Orders for data over the area covered by IRS-1C within the visibility area of NRSA Data Reception Station can be directly placed with

NRSA Data Centre,
National Remote Sensing Agency,
Balanagar,
Hyderabad - 500 037.
(Phone No.040-278560, 279572 Fax No.040-278664, 278648).

For data products over other areas users can approach

Customers Service Department,
EOSAT Company,
4300, Forbes Boulevard,
Lanham,
Maryland, 20706, USA,
(Phone No.301-552-0571, Fax No.301-552-5476).

The following data products are available:

IRS-1C Panchromatic Camera (PAN) Products
PAN sub-scenes (23km x 23km nadir view)
PAN mapsheet based geocoded product of $7\frac{1}{2}' \times 7\frac{1}{2}'$ area
PAN point geocoded products covering 5'x5' area

LISS-III Products
Full scene, path row based
Full scene, path row based, shift along track Quadrant
Geocoded (15' x 15' area)

WiFS Products
WiFS products from both IRS-1C and IRS-P3 satellites are available. Since IRS-1C WiFS has only two bands, FCCs are generated using band-3 data twice. IRS-P3 has a similar product, in addition to three band FCC (Band 3,4,5). WiFS data can now be supplied as follows:

IRS-1C WiFS with band 3,3,4
IRS-P3 WiFS with band 3,3,4 and 3,4,5

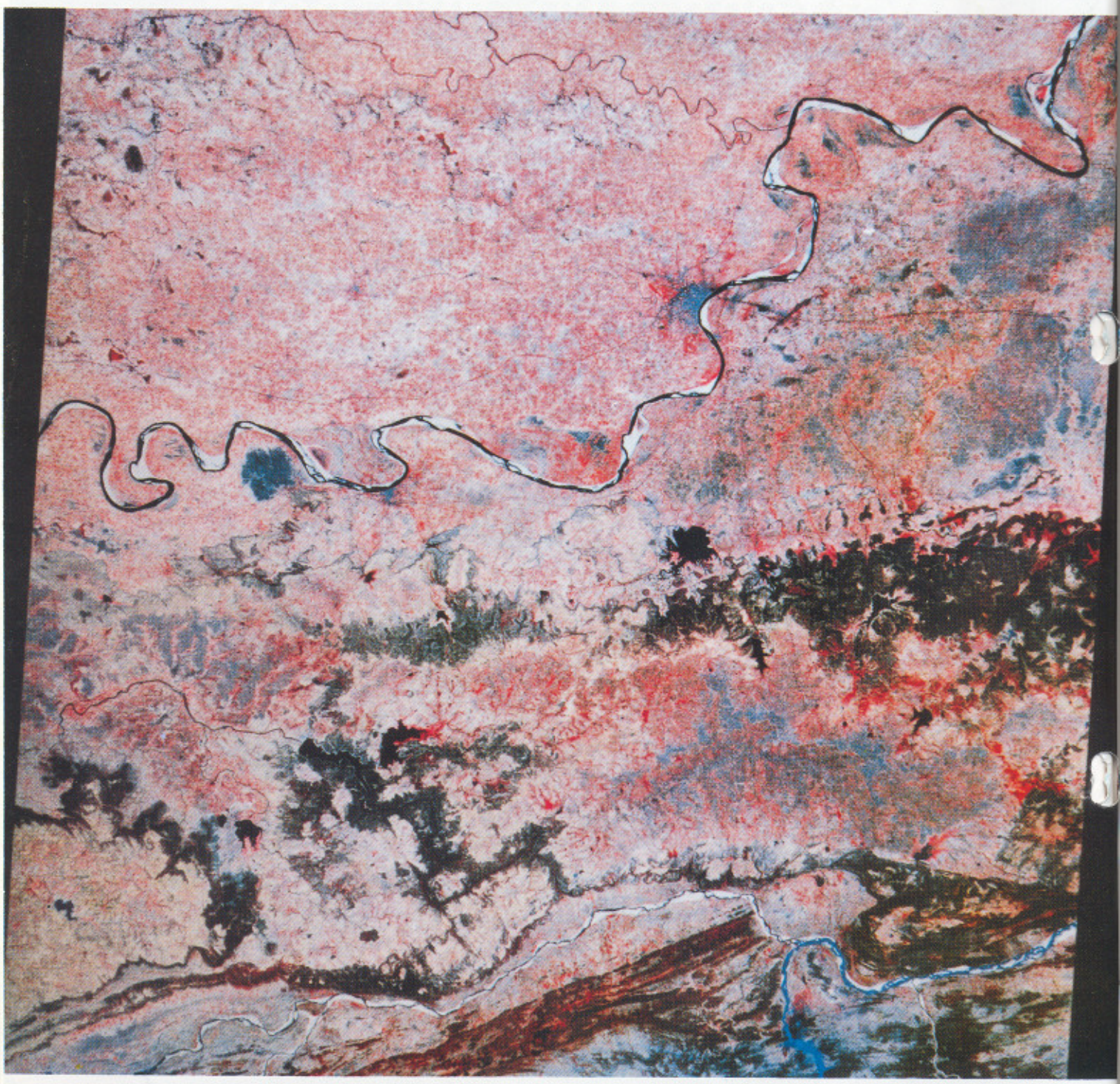
The data products are available on Computer Compatible Tapes (CCTs) Cartridges (525 MB)
8 mm Exabyte Tapes.
Photographic Black and White false colour composite are available on 240 mm positive and negative films and 240/480/960/1000 mm paper prints. The scales range from 1:12,500 to 1:500,000.
IRS-1C referencing map, orbital calendar, price-lists and hand-book are available from NDC to assist users for placing orders for data products. Digital browse facility has also been set up at NDC for LISS-III and PAN camera data to enable customers select the data to be ordered.

Already, IRS-1C data is being received by several agencies in Northern America and European countries through a commercial arrangements with the Antrix Corporation of the Department of Space and the EOSAT Co, USA. Japan, Australia and Thailand are setting up stations for IRS-1C data reception in their respective regions. It is expected that another ten countries will sign agreements for receiving the data soon.
Thus, IRS-1C has already become an important source for the world community for a variety of space-based remote sensing data.

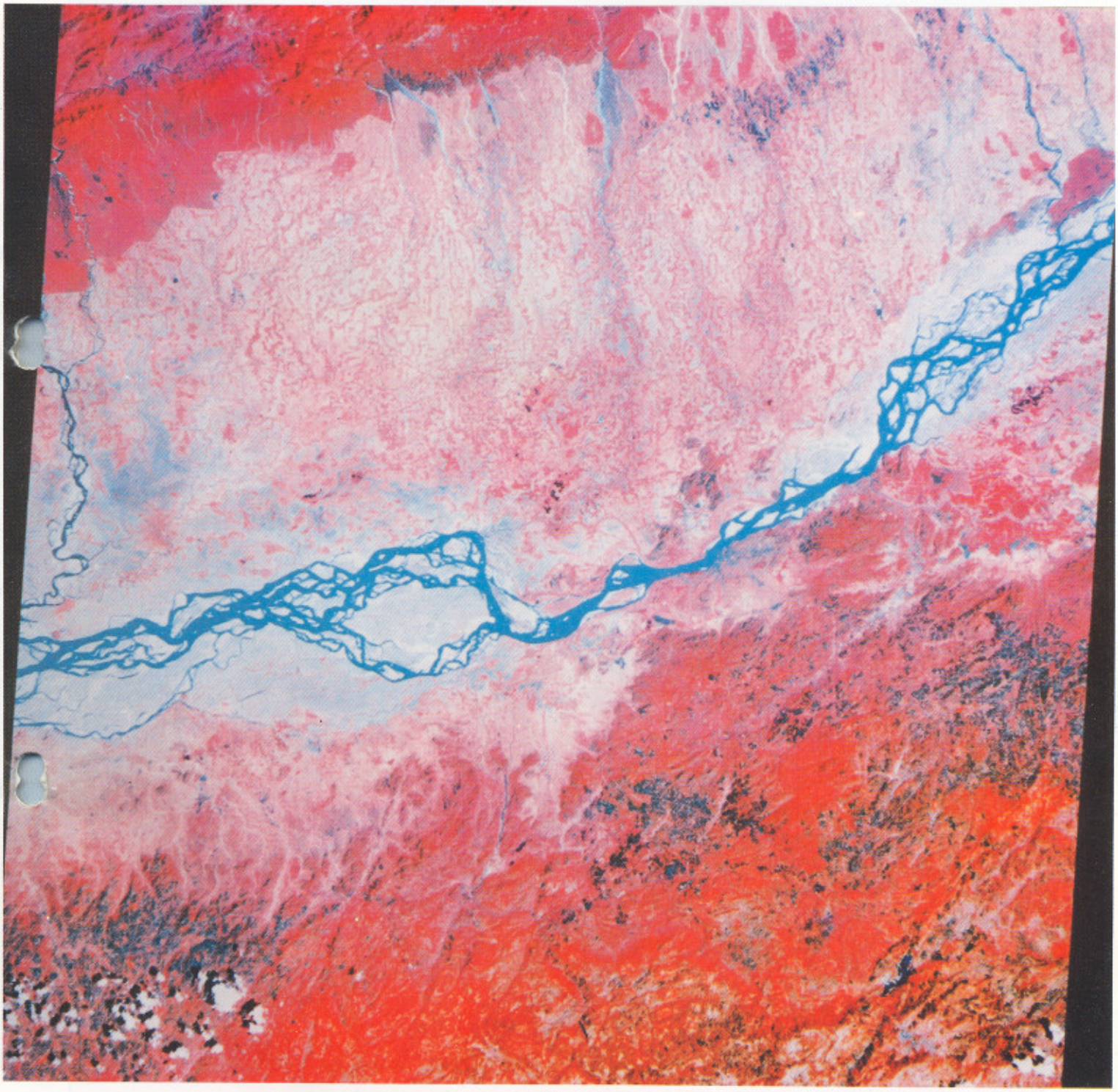
IRS-1C PAN data of Washington City

BANGALORE AND ENVIRONS

(PAN+LISS3 OF IRS-1C ACQUIRED ON 20-JAN-1996)



IRS-1C LISS-III imagery showing parts of Uttar Pradesh near Varanasi



IRS-1C LISS-III imagery of North-Eastern parts of India showing Brahmaputra river

IRS-1C LISS-III imagery showing part of Andhra Pradesh. The river Krishna can be seen at the top.

Indian Satellites in Operation

Sl. No.	Satellite	Date of launch	Orbit	Payload
1.	INSAT-1D	June 12, 1990	Geostationary (located at 83°E Longitude)	Twelve C-band transponders, two S-band transponders, three data relay transponders, Very High Resolution Radiometer (VHRR)
2.	INSAT-2A	July 10, 1992	Geostationary (located at 74°E Longitude)	Twelve C-band transponders, six extended C-band transponders, two S-band transponders, data relay transponder, search and rescue transponder, VHRR
3.	INSAT-2B	July 23, 1993	Geostationary (located at 93.5°E Longitude)	Twelve C-band transponders, six extended C-band transponders, two S-band transponders, data relay transponder, search and rescue transponder, VHRR
4.	INSAT-2C	December 7, 1995	Geostationary (located at 93.5°E Longitude)	Twelve C-band transponders, six extended C-band transponders, two S-band transponders (one for mobile communication), three Ku-band transponders
5.	IRS-1B	August 29, 1991	904 km Polar sunsynchronous	Two CCD-based Linear Imaging Self-Scanning cameras (LISS), One LISS-1 with 72.5m resolution and two LISS-II with 36.25 m resolution
6.	IRS-P2	October 15, 1994	817 km Polar sunsynchronous	LISS-II camera with 32 x 37 m resolution.
7.	IRS-1C	December 28, 1995	817 km Polar sunsynchronous	LISS-III with 23.5 and 70.5 m resolution, Panchromatic (PAN) with 5.8 m resolution, Wide Field Sensors (WiFS) with 188 m resolution
8.	IRS-P3	March 21, 1996	817 km Polar sunsynchronous	WiFS with 182x188 m (Red and NIR) resolution and 246x188 m resolution (SWIR), Modular Opto-Electronic Scanner (MOS) with 523 m resolution and X-ray astronomy
9.	SROSS-C2	May 4, 1994	437 km x 938 km	Gamma-Ray Burst Detector and Retarding Potential Analyser

India as seen by Wide Field Sensor of IRS-1C