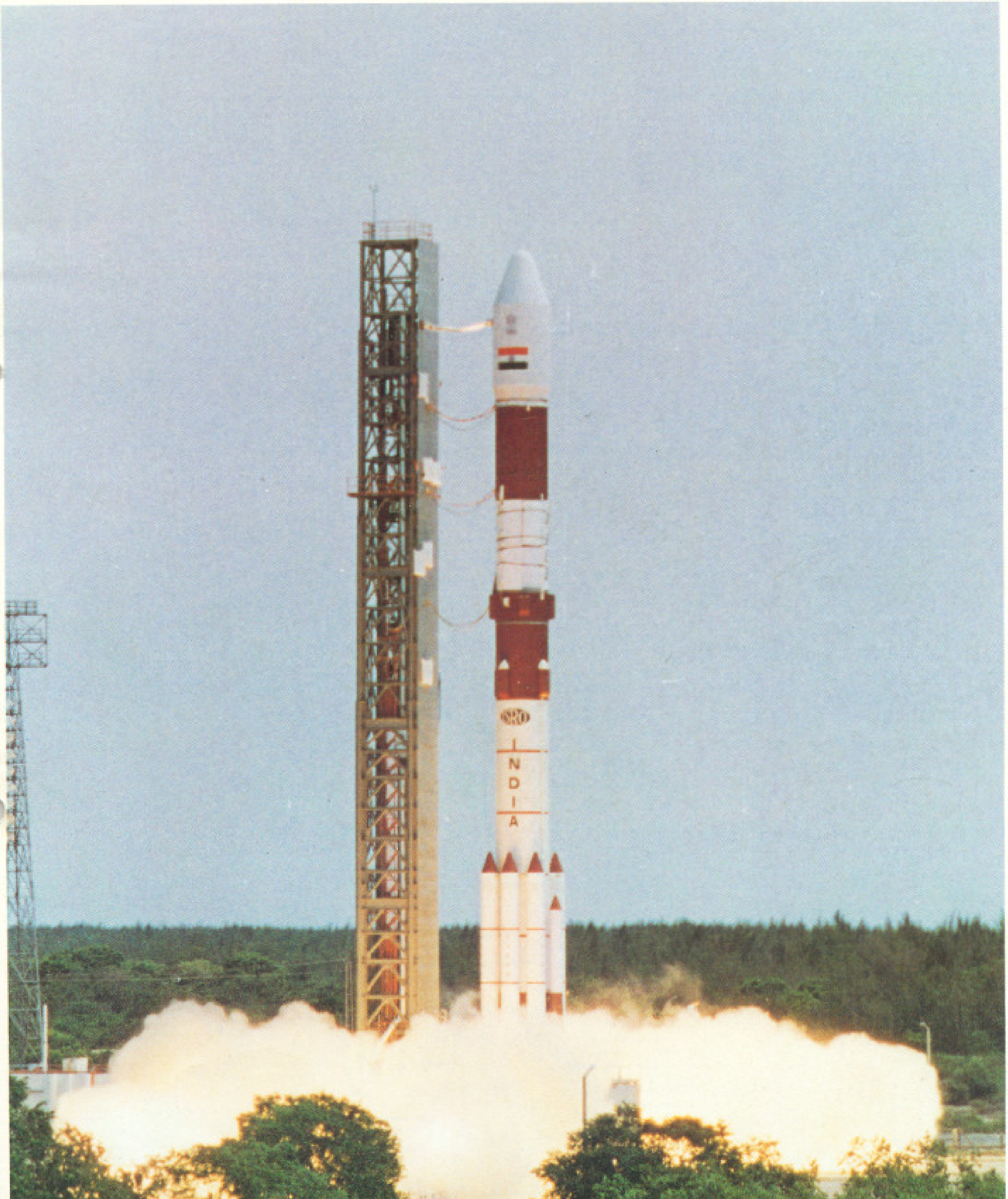
JULY - SEPT. '93

SPACE india



INDIAN SPACE RESEARCH ORGANISATION

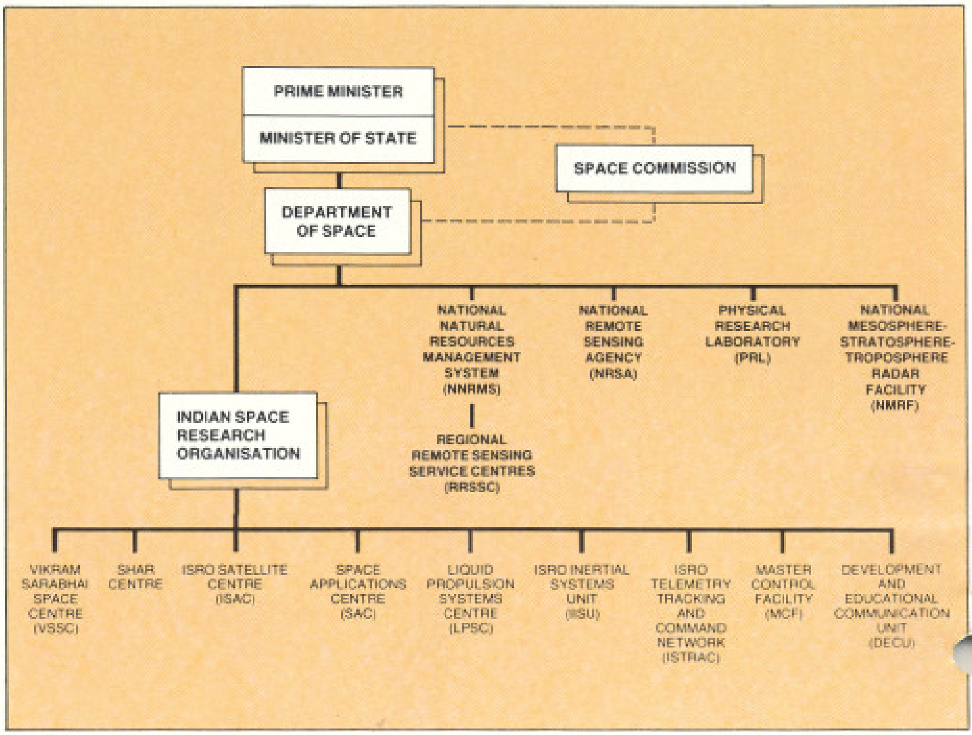
The Indian Space Programme

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

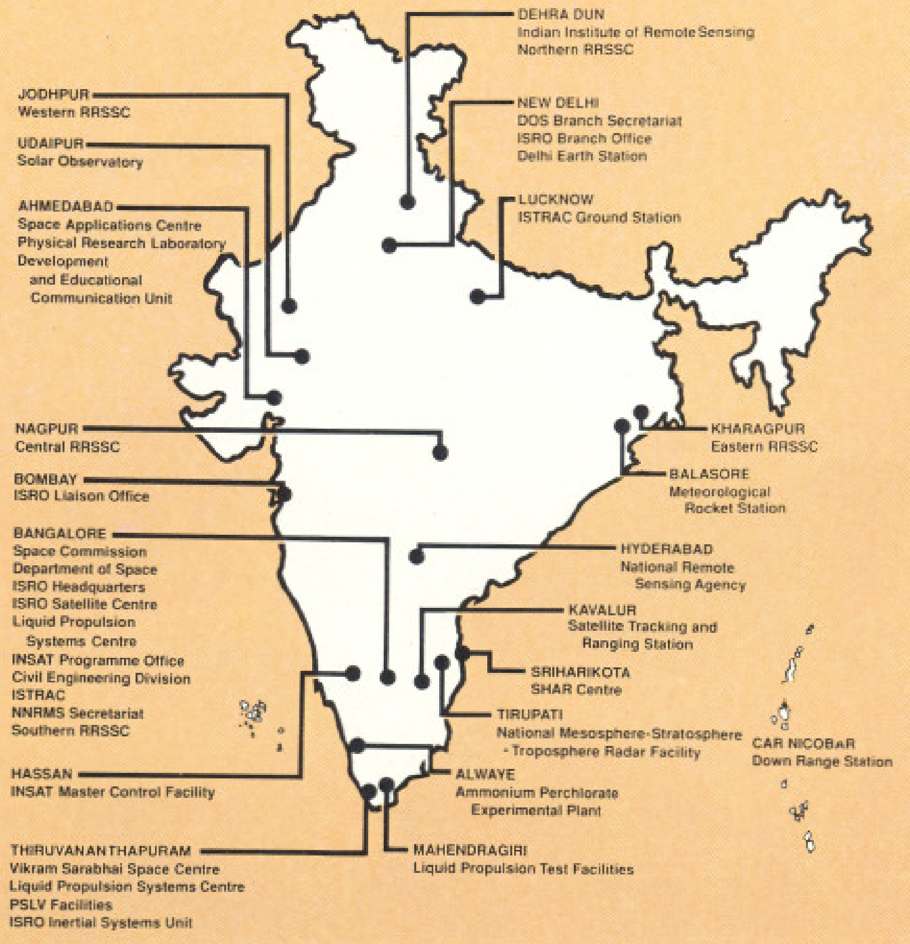
The Indian Space Programme is directed towards the goal of self-reliant use of space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological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

The Indian Space Research Organisation (ISRO) is the research and development wing of DOS and is responsible for the execution of the national space programme. ISRO also provides support to universities and other academic institutions in the country for research and development projects relevant to the country's space programme.

Both the DOS and ISRO Headquarters are located at Bangalore. The development activities are carried out at the Centres and Units spread over the country. ☐



SPACE CENTRES AND UNITS IN INDIA



FRONT COVER
PSLV lift-off

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Contents

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First Developmental Flight of PSLV

A view of the launch complex with PSLV on the launch pedestal

The first developmental flight of the indigenously developed Polar Satellite Launch Vehicle (PSLV-D1) took place on September 20, 1993 from the Sriharikota Launch Complex, about 80 km north of Madras. PSLV-D1 carried an 846 kg IRS - 1E satellite. Though the launch vehicle was not able to attain the required injection altitude and velocity to place the satellite in the intended 817 km polar orbit, almost all the individual subsystems of the vehicle associated with propulsion, structures, aerodynamics, control, navigation, guidance and electronics performed normally.

The launch campaign for the PSLV-D1 flight had commenced in May 1993 with the stacking of the 25 tonne nozzle-end segment of the first stage. The assembly of all the four stages and the pyro devices, check out of the electrical and mechanical interfaces went on smoothly; finally, the integrated vehicle was checked out using an automatic check out system employing four mini-computers and forty micro-computers located in the Launch Control Centre (LCC), about six km away from the launch tower.

The IRS -1E spacecraft, carrying the Monocular Electro - Optical Stereo Scanner (MEOSS) payload supplied by the German space agency, DLR and the Linear Imaging Self-Scanner (LISS) payload of ISRO, was mated with the launch vehicle ten days before launch. This was followed by detailed checks of compatibility between the vehicle and spacecraft.

The final countdown for the launch, which was originally scheduled for September 19, 1993, commenced at T-72 hours (T being the launch time), with the filling of non-hazardous fluids such as strontium perchlorate for the SITVC, helium and nitrogen gas. Later the propellants (MON, MMH, N_2O_4 and UDMH) filling operations for the second and fourth stages were carried out using the automated system. Arming operations for nearly 160 on-board pyro elements formed a major part of the countdown. Different phases of pressurisation of all high pressure systems were also carried out. From T-8 hours

A close-up view of the vehicle

PSLV Lift-off

onwards the warming up of inertial sensors, their calibration and alignment as well as detailed checks on flight computers, instrumentation and power supply were carried out.

The countdown had to be held at T-3 hours on September 19, 1993 due to an anomaly detected by the checkout computer. Analysis, however, indicated that the on-board systems were normal and that the anomaly was due to an error in the decoding of data by the checkout computer. The launch was rescheduled for the next day, that is September 20, 1993, with launch window fixed between 1014 - 1054 hours IST. The countdown was resumed at T-10 hours on the night of September 19, 1993, There were three more minor holds during the final phase of countdown; these were cleared after ensuring that the health of vehicle was normal. During the last 10 minutes, nearly 50 commands were issued by the Automated Launch Processing System (ALPS). The ALPS also monitors nearly 500 parameters on the health of the on-board systems and can hold the countdown automatically in case of any deviation beyond specified limits.

Three seconds before lift-off, the two reaction control thrusters of the first stage were ignited and their normal functioning confirmed by the ALPS. From then onwards, nearly sixty events were automatically commanded in flight by the on-board computer.

The first stage (PS -1) thrust built up in about 600 milli seconds after the ignition command and lift-off of the vehicle detected by the snap of the last minute plug at T+860 milli seconds. Detection of this event by computer set in motion the flight events, some of which were preprogrammed and others were based on real-time detection of specified events on board. Two strap-on motors were ignited at T+1.3 sec and the vehicle rose vertically for 5 seconds by which time it cleared the umbilical mast.

The lift-off, one of the most critical phases for any flight, was normal. Inspection of the launch pad later indicated that the launch pedestal and the umbilical mast which experienced the full blast of the first stage exhaust were practically intact. Several new technologies involving vehicle-launch pad interface such as the launch pedestal, jet deflector, thermal protection, lift-off dynamics were thus validated.

The roll command was given at T+5.9 seconds to roll the vehicle by 5 degrees and to align it to 140 degree azimuth after which the pitch programme was initiated. The atmospheric regime of the flight is perhaps the most difficult for any launch vehicle because of

PSLV Launch Control Centre

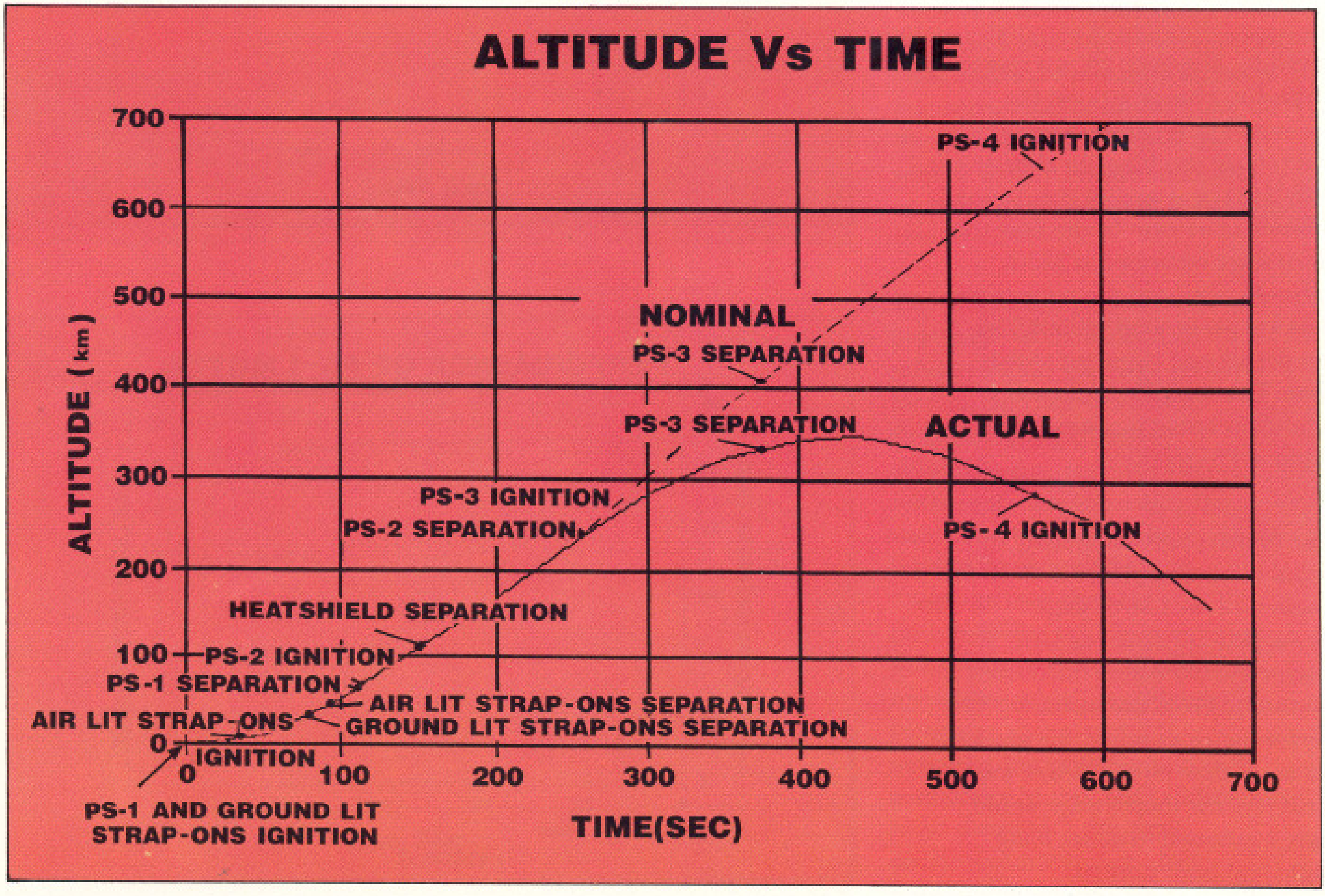
the associated aerodynamic, structural and control problems. To reduce the severity of these problems, the stage was put on gravity turn flight path till the burn-out of the first stage. In the event, this regime of the PSLV-D1 flight turned out to be remarkably smooth. The main motor reached its peak performance at 17 seconds delivering a thrust of 460 tonnes. The remaining four strap-on motors were ignited at T+30.3 seconds. The transonic regime occurred around 35 seconds at an altitude between 4 and 5 km. The maximum disturbance to the vehicle was noticed around 62 seconds at about 16 km altitude when the dynamic pressure was high and atmospheric winds reached their maximum. The flight, when PS -1 and all the six strap-on motors were burning simultaneously, was smooth and as per prediction. The two ground-lit strap-on motors separated from the vehicle at 73.3 seconds and the four air-lit strap-on motors separated at 90.3 seconds as designed. The first stage burn out was detected by the on- board computer at 103.6 seconds. The most difficult task of controlling the attitude of the vehicle during the transonic, high dynamic pressure and heavy wind conditions was carried out perfectly by the digital auto pilot using the SITVC (Secondary Injection Thrust Vector Control) and reaction control thrusters.

After the burn-out of the first stage, the vehicle was allowed to coast freely for a period of 5 seconds when the tail-off thrust reduced sufficiently for PS -1 separation. The auxiliary control system during the transition between first and second stage came on as desired. The ullage rockets were fired at 105.2 seconds to ensure positive acceleration for the vehicle so that the liquids in the second stage stay in place. The command for PS-1 separation at 108.6 seconds was followed by ignition of second stage (PS -2) in 200 milli seconds. The separation was effected using FLSC system initiated through a remote-mounted safe-arm unit. The pull out of the second stage nozzle from the 4.7 m long interstage was effected using 8 retro rockets. The staging event between PS -1 and PS-2 was the most critical in the entire flight regime.

The PS -2 engine developed the full thrust of 72 tonne within 2.8 seconds as expected and its performance was steady throughout the burn duration of 152 seconds. The initial disturbance to the vehicle was captured by the attitude control systems with the use of engine gimbal control actuators. At the beginning of the second stage propulsion the yaw manoeuvre was commenced so as to put the vehicle along its polar path from 140 degrees azimuth which meant that its ground trace was along the Indian and Sri Lankan coast in the international waters. The 3.2 m diameter and 8.3 m long heatshield was separated into two halves and jettisoned at 155.6 seconds while the vehicle was thrusting. The merman band and zip cord system of the heatshield performed normally without causing any disturbance to the vehicle or the spacecraft on board. Immediately thereafter the closed

PSLV-D1 Accomplishments

- *Proving the giant solid propellant booster along with the six strap-on motors in the most difficult flight phase through the atmosphere*
- *Flight testing of the two liquid propulsion stages for the first time*
- *Evaluation of the performance of the third stage solid propellant motor*
- *Altogether, 10 major rocket motors were flight proven and 30 other small motors were tested under various environments in flight*
- *Flight evaluation of RESINS with a performance matching with the tracking data from precision radars*
- *Linking of six on-board computers in redundant configuration to carry out the flight management functions of navigation, guidance, digital auto pilot and sequencing*
- *Evaluation, in flight, of new control systems using engine gimbal and flex nozzle*
- *Qualification of large light alloy structures*
- *Qualification of large bulbous heatshield employing isogrid technology*
- *Development of a variety of control components and control systems*
- *Reliable pyrotechnic systems*
- *Variety of stage separation devices and heatshield jettisoning system*
- *The mission integration and management involving a host of complex technologies*

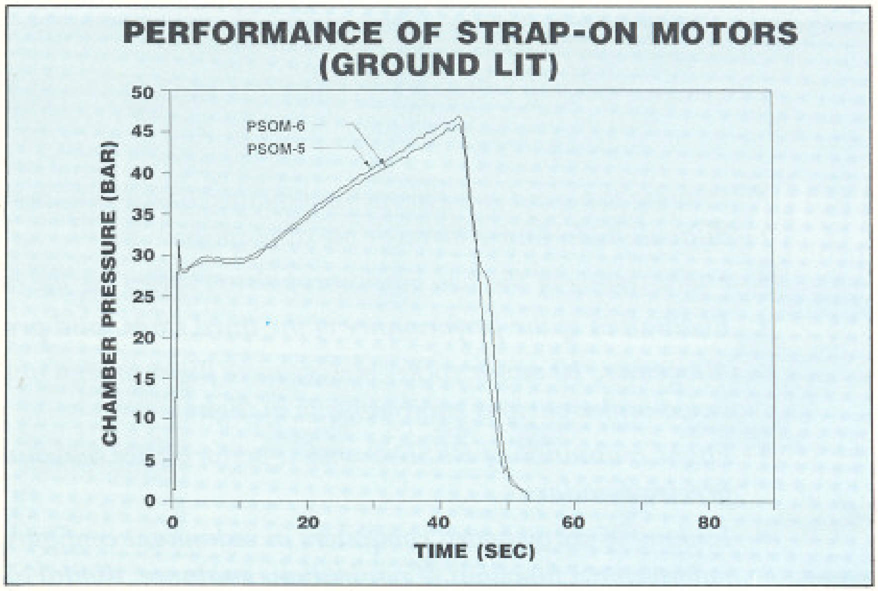

ALTITUDE Vs TIME

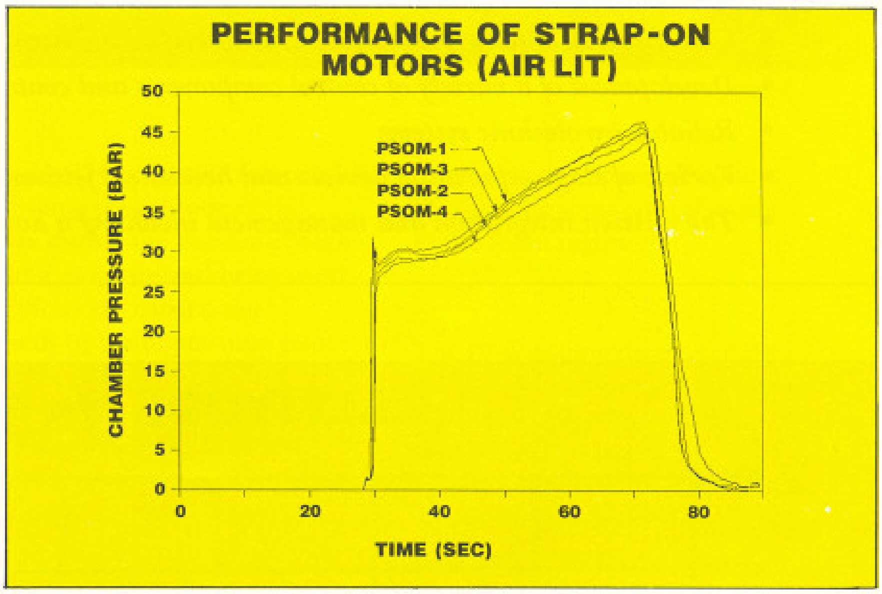
loop guidance was initiated for position and velocity correction to the vehicle to achieve the injection of the spacecraft into the specified orbit.

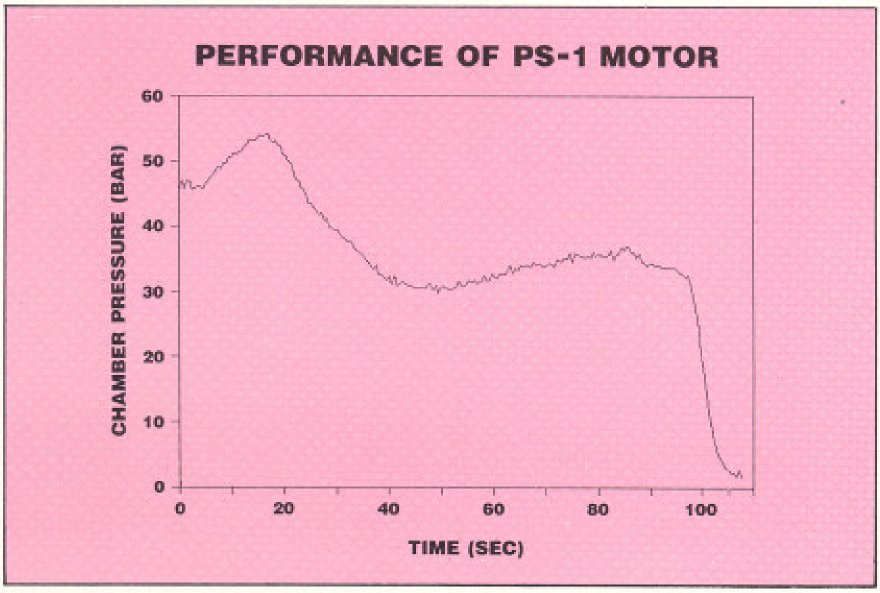
The tail-off of the second stage was detected at 261.5 seconds which initiated subsequent sequence of events. The separation commands were issued three seconds later and the ignition command for the third stage 1.2 seconds thereafter as planned. When the third stage was ignited at 265.7 seconds, the vehicle was at an altitude of 249.5 km with a velocity of 3.83 km per second. The trajectory upto this moment as measured by the Redundant Strap-down Inertial Navigation System (RESINS) and telemetry matched with that observed by the high precision tracking radars at Sriharikota and Thiruvananthapuram.

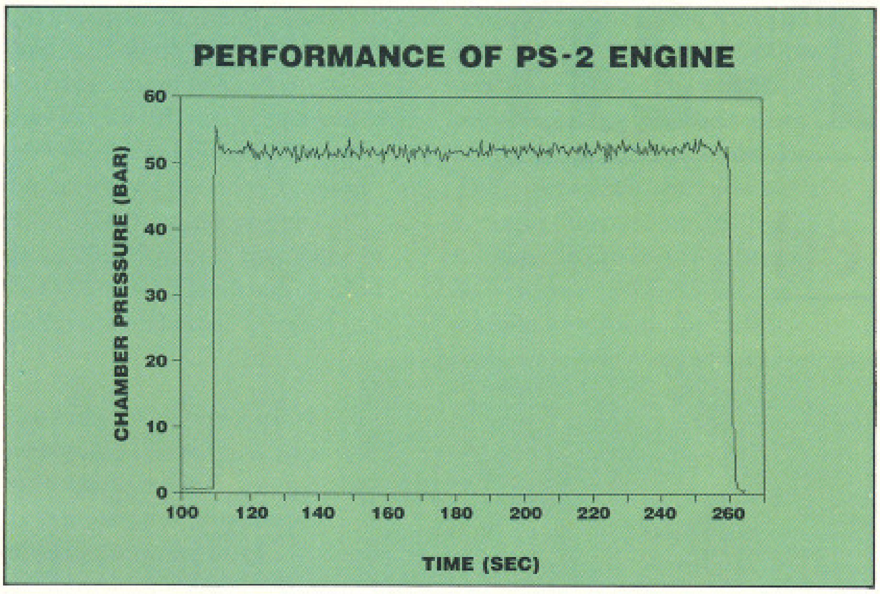
The telemetered chamber pressure history of the third stage confirmed normal performance for a total duration of about 81 seconds. However, an unexpected large disturbance around the second stage separation resulted in the vehicle reaching an altitude of only 340 km as against the planned altitude of 414 km by the time the third stage separated at 383.8 seconds. Similarly, the velocity was 3.54 km per second against 5.98 km per second expected at that time. This loss of velocity and altitude resulted in a sub-orbital flight of PSLV-D1.

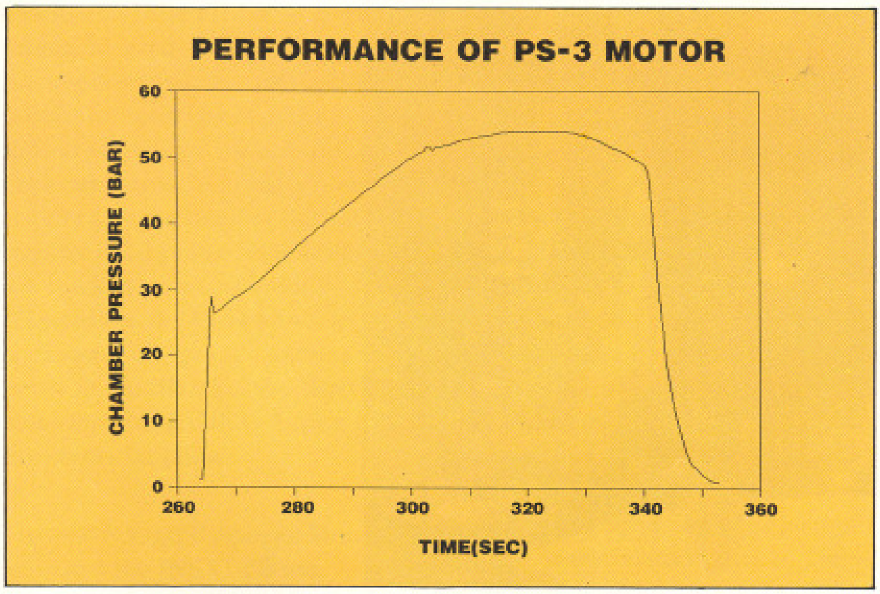
The fourth stage was ignited at 565.2 seconds as planned. Both the engines of the fourth stage developed full thrust and the engine gimbal system functioned normally. From the steady performance shown by the engines for more than 80 seconds, it was clear that the fourth stage would have continued to do so, if the flight had been normal.

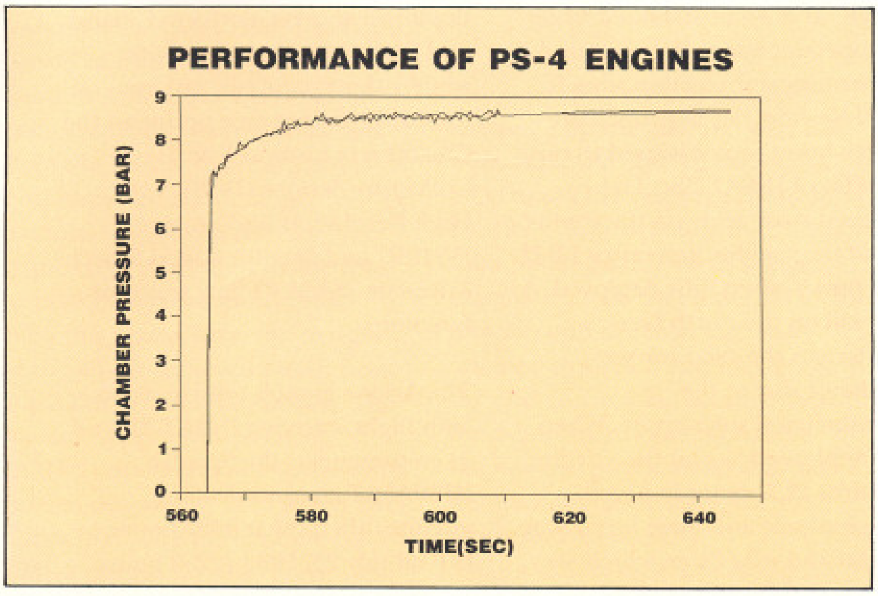

PERFORMANCE OF STRAP-ON MOTORS (GROUND LIT)


PERFORMANCE OF STRAP-ON MOTORS (AIR LIT)


PERFORMANCE OF PS-1 MOTOR


PERFORMANCE OF PS-2 ENGINE


PERFORMANCE OF PS-3 MOTOR


PERFORMANCE OF PS-4 ENGINES

The telemetry data confirmed normal performance of all the subsystems during the entire regime of flight data recorded for 693 seconds.

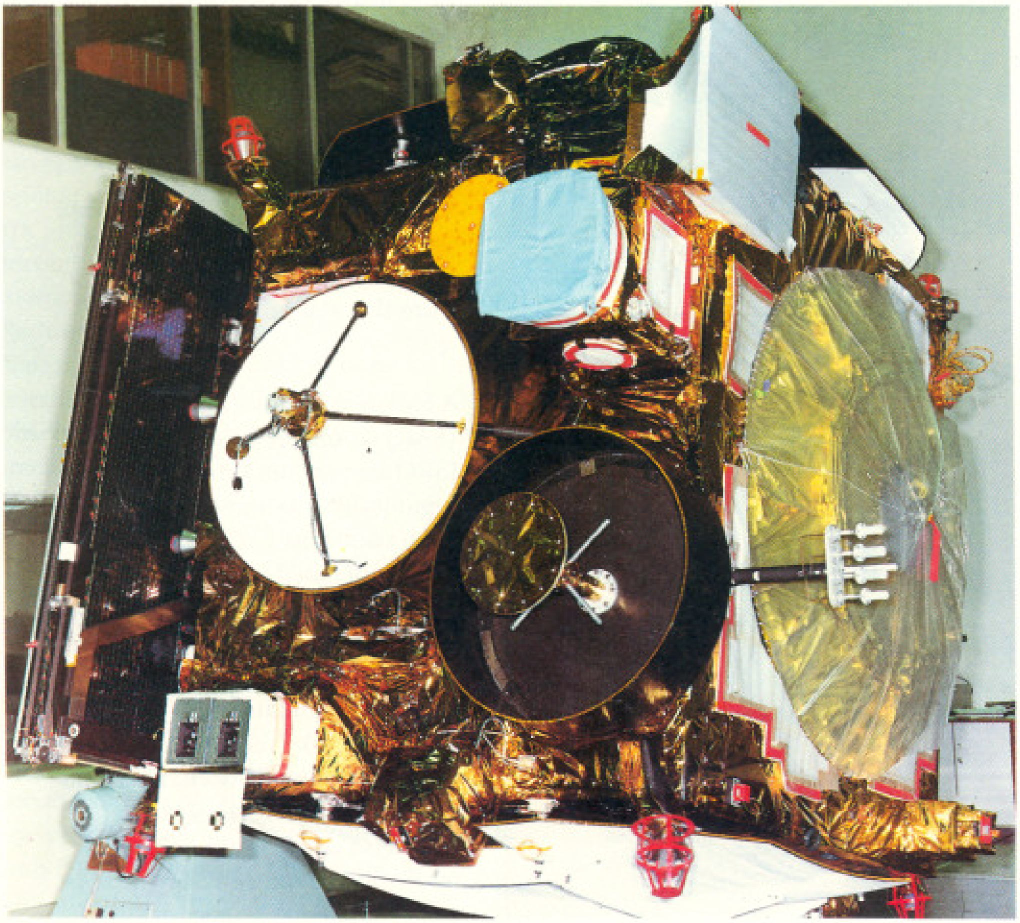
The ground stations at SHAR and Thiruvananthapuram recorded good quality telemetry data. The vehicle was tracked by high precision C-band radar and S-band range and range rate system. Nearly one billion of bytes of data were recorded. The down range station at Mauritius, however, could not receive any data because the vehicle did not attain the altitude necessary to be visible from that station.

A Failure Analysis Committee (FAC) comprising experts from ISRO and various other organisations in the country has been constituted. The FAC will make a detailed scrutiny of all flight data and establish as precisely as possible the reasons for the failure of the PSLV-D1 to place the IRS-1E satellite in the intended orbit and make recommendations regarding modifications, if any, on the systems/subsystems of the vehicle so as to ensure successful realisation of future PSLV missions.

The satisfactory performance of practically all the individual subsystems like the large rocket motors, the control systems, guidance, navigation and auto-pilot, structural hardware, software for implementing the various on-board functions, mission design and launch campaign management encompassing vehicle integration, propellant servicing, checkout operations as well as real-time computer system and TTC networks, has generated enough confidence in the ISRO community to go ahead with the next developmental launch after necessary modifications. □

INSAT-2B

Commissioned



INSAT - 2B Spacecraft

After a successful launch on July 23, 1993 by the Ariane vehicle of Arianespace, INSAT-2B was declared operational on August 10, 1993. INSAT-2B is the second of the indigenously built multipurpose INSAT-2 series of satellites. The first satellite, INSAT-2A, launched on July 10, 1992, is located at 74° east longitude. It is providing all the operational services to the nation for which it is designed since its commissioning in August 1992.

INSAT-2B is identical to INSAT-2A and weighs about 1,906 kg at launch. It is 3-axis stabilised using bi-propellant micro-thrusters and momentum and reaction wheels. A 440 Newton (N) bi-propellant apogee boost motor is used to raise the orbit of INSAT-2B. The T-shaped solar array on the south face of the satellite generates 1,042 W of power when fully deployed. A solar sail on the north face counteracts the solar torque imbalance due to the unsymmetrical solar array. When fully deployed in orbit the satellite measures 22.5 metre in length. Two parabolic antennae located on the east and west faces, which are deployed in orbit, perform C-band and S-band transmit functions, while a third parabolic antenna on the earth-viewing face performs the C-band receive as well as Data Collection Service (DCS), Very High Resolution Radiometer (VHRR) and Satellite-Aided Search & Rescue (SAS&R) data transmit functions.

The Ariane launch vehicle, on its 58th flight, carrying INSAT-2B and its co-passenger, the Spanish HISPASAT communication satellite, lifted-off at 0429 hours IST on July 23, 1993 (2259 hours

GMT on July 22, 1993), from Kourou, French Guyana in South America. About twenty minutes after the lift-off, the Ariane launch vehicle injected INSAT-2B satellite into a Geosynchronous Transfer Orbit (GTO) with a perigee of about 200.3 km and an apogee of 35,957 km, with an orbital period of about 10.5 hours.

The Master Control Facility (MCF) at Hassan in Karnataka acquired the satellite telemetry signal about six minutes after satellite's injection into the orbit. Immediately thereafter, the satellite health check was performed and a series of commands issued from MCF to orient the earth- viewing face of the satellite towards earth and the outermost solar panel of the stowed solar array towards sun for generating the electrical power required by the satellite during the transfer orbit phase. The satellite was tracked, apart from MCF (Hassan) by the INTELSAT organisation's ground stations at Perth (Australia), Fucino (Italy) and Clarksburg (USA) during the transfer orbit phase.

The 440 N Liquid Apogee Motor on board the INSAT-2B was successfully fired (AMF-1) on July 24, 1993 at 0643 hours IST, theraby placing the satellite in its first Intermediate Orbit (IO-1) with a period of 15.5 hours. The 58 minutes AMF-1 was a very major manoeuvre and was commanded from the Master Control Facility. This imparted about 62 per cent of the total velocity increment required to push the satellite into its final geosynchronous orbit. With this manoeuvre, the perigee of INSAT-2B orbit was raised from 200.3 km to about 20,800 km. The second Apogee Motor Firing (AMF-2) operation was successfully carried out on July 25, 1993 at 1327 hours IST. The 22.5 minutes of AMF-2 put the satellite in its second Intermediate Orbit (IO-2) with a period of about 22.4 hours, very close to the final orbital period with the perigee having been raised to about 32,060 km. The spacecraft inclination was also brought down from 6.99 degree (at the time of injection) to very nearly zero degree. With AMF-2 the satellite was within the radio visibility of MCF, continuously. The third and final orbit raising manoeuvre was carried out on July 27, 1993, by firing the Apogee Motor (AMF-3) for about 127.4 seconds at 1003 hours IST. The spacecraft thus entered the near geostationary orbit around 72 degree east longitude with a small drift of 3.5 degree per day towards its final location of 93.5 degree east longitude.

Critical operations involving the deployment of the solar array on board was completed on July 28, 1993. The deployment of the 15.5 sq. m area solar array comprising three panels of 3.9 sq. metre each and two panels of 1.9 sq. m each which generates about 1058 W of electrical power was achieved in two phases; first, the three main panels were deployed in an accordion fashion, followed by the release of the two side panels. The solar array drive mechanism was enabled to make the array continuously face towards the sun.

The two 1.8 m x 1.8 m parabolic antennae on the east and west side were deployed at 0712 hours and 1630 hours IST respectively on July 29, 1993. Subsequently the 14.5 m solar boom on the north side was extended slowly over a period of 16 minutes and the solar sail, was released to stretch and lock up at the end of the solar boom. After the deployment operations, the satellite was put in on-orbit 3- axis stabilisation mode using the two momentum wheels.
After a trim manoeuvre to reduce

INSAT-2B Characteristics

General

Orbit	Geostationary
Location	93.5 deg. east
Life	9 years (minimum)
Type	3-axis stabilised

Payload

Fixed Satellite Service (FSS)	18 transponders, (12 C-band and 6 Extended C-band); 32 dBW eirp : 16 no. and 34 dBW eirp : 2 no.
Broadcast Satellite Service (BSS)	2 S-band transponders : 42 dBW
Very High Resolution Radiometer (VHRR)	2 km resolution in visible & 8 km resolution in IR band
Data Relay Transponder (DRT)	400 MHz uplink, Ext.C-band downlink
Satellite-Aided Search and Rescue (SAS&R)	406 MHz uplink, Ext.C-band downlink

Power

Summer Solstice Power	1042 W (End of Life)
Eclipse Power	560 W
Battery	Ni-Cd : 2 no. 18 Ah each

TT & C

TC & Ranging Rx band	6410-6425 MHz
TM & Ranging Tx band	4185-4200 MHz

AOC

Pointing accuracy	Pitch & Roll : ±0.2 deg Yaw : ±0.4 deg
3-axis control	Two momentum wheels, one reaction wheel

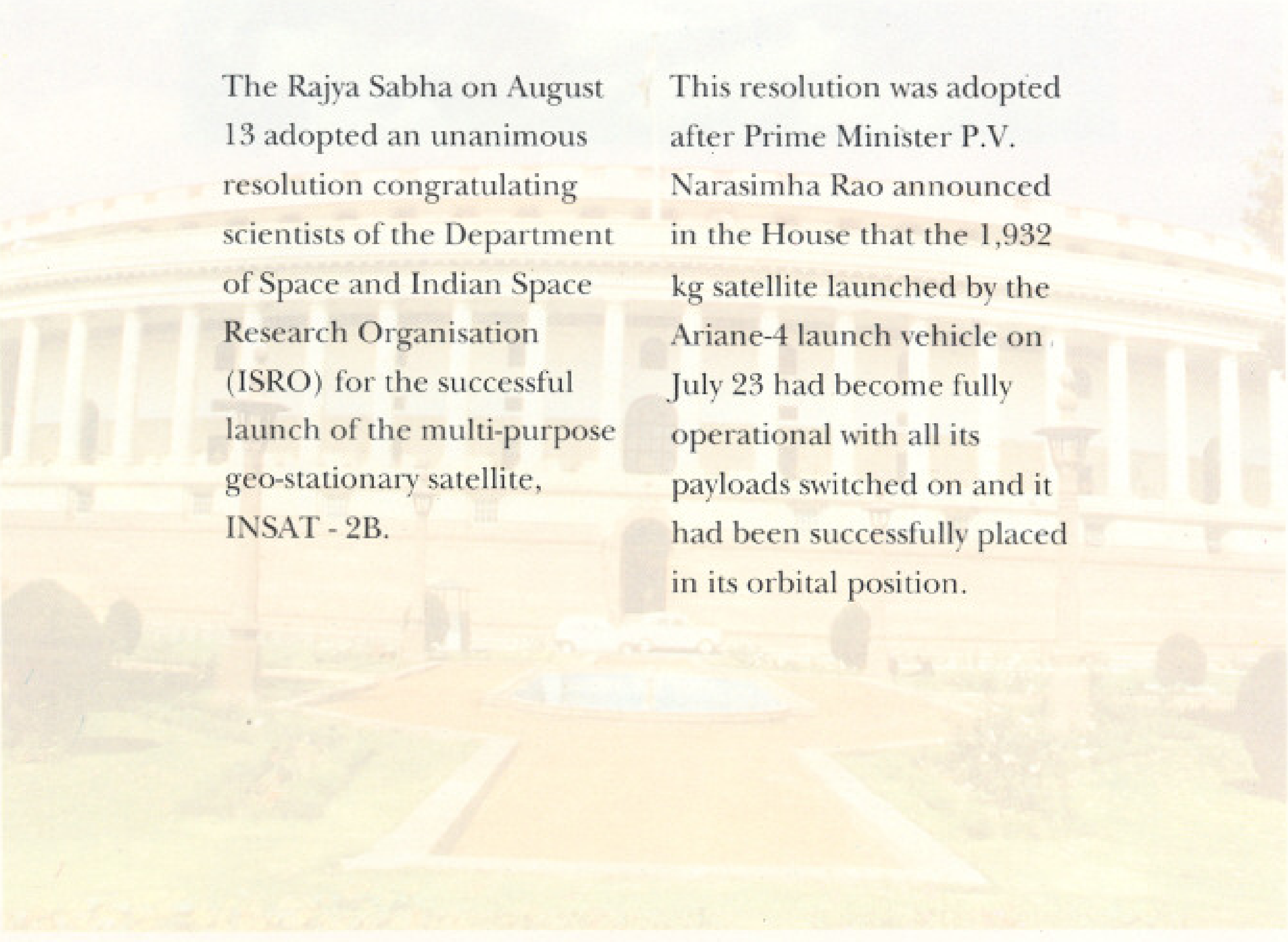
Mechanical

Body dimensions	1.93m x 1.64m x 1.70m
Length	22.5 m (fully deployed)
Lift-off mass	1,906 kg
Dry mass	901 kg
Liquid Apogee Motor	440 N
Thrusters	22N each (16 no.)
C/S antennae	1.77m x 1.77m (parabolic:2 No.)
CxC antenna	0.9m dia : (1 No.)
UHF receive antenna	0.75m (1 No.)
TTC omni antenna	Main antenna (quadri filler helix) Null-fill antenna (axial mode helix)
Global horn antenna	0.3m dia (1 No.)
Solar array ("T" shaped after deployment)	Main panels : 1.8m x 2.15m (3 No.) Side panels : 1.8m x 1.07m (2 No.)
Solar sail	Dia 1.5m, length 4.38m (cone shaped)
Solar boom	Dia 0.3m, length 14.45m

INSAT - 2 Master Control Facility at Hassan the drift rate to 1.5° per day on July 31, 1993, the Very High Resolution Radiometer (VHRR), meant for taking cloud cover imagery over the Indian Ocean region was switched 'on' and the first imagery in the visible band commanded at 1130 IST. Later, the six Extended C-band transponders, the 406 MHz Data Relay Transponder and the Search and Rescue Transponder were also switched on'. The twelve normal C-band Transponders were switched 'on' on August 1, 1993 and the two high-power S-band Transponders were energised on August 2, 1993. INSAT-2B, reached its allotted orbital slot of 93.5 degree east longitude on August 6, 1993 when the drift was arrested. After detailed test, evaluation and characterisation of the transponders and the meteorological payloads including the VHRR, INSAT-2B was declared operational on August 10, 1993.

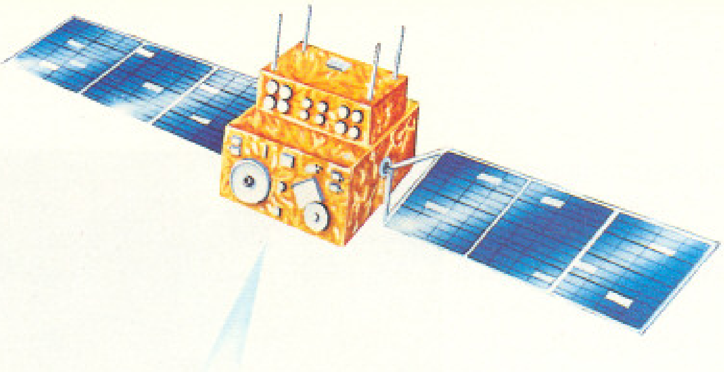
The INSAT system, established in 1983 with the commissioning of INSAT-1B, is a joint venture of Department of Space (DOS), Department of Telecommunications (DOT), India Meteorological Department (IMD), All India Radio (AIR) and Doordarshan. INSAT-2B, together with INSAT-2A and INSAT-1D launched in June 1990, has improved significantly the INSAT space segment capacity for telecommunication, direct TV broadcasting and nationwide TV distribution, radio networking, meteorological observation and data relay. □

Space Scientists Congratulated



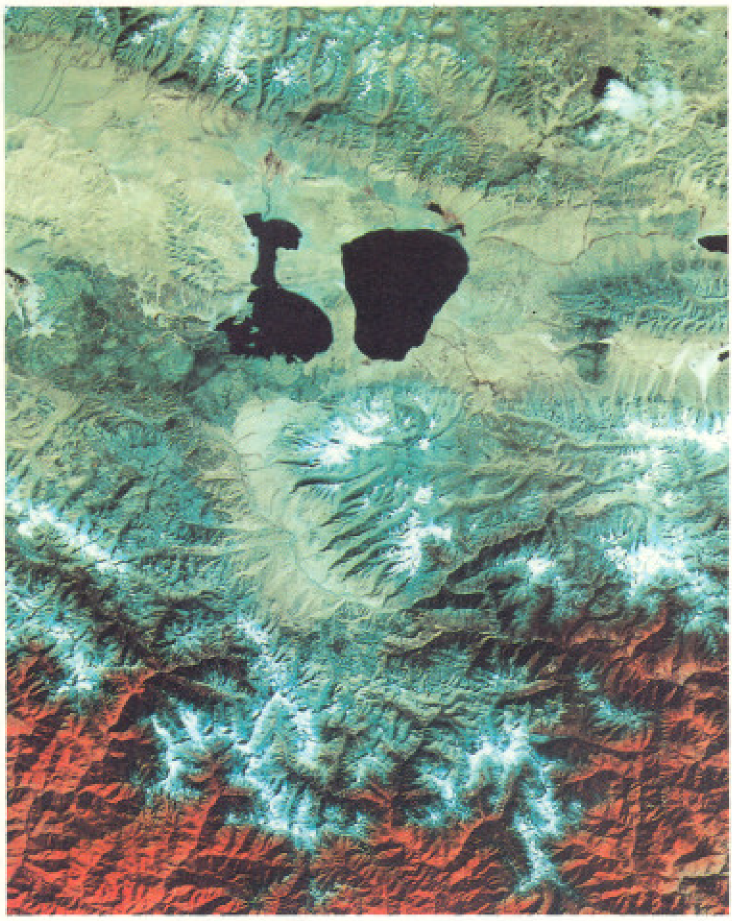
The Rajya Sabha on August 13 adopted an unanimous resolution congratulating scientists of the Department of Space and Indian Space Research Organisation (ISRO) for the successful launch of the multi-purpose geo-stationary satellite, INSAT - 2B.

This resolution was adopted after Prime Minister P.V. Narasimha Rao announced in the House that the 1,932 kg satellite launched by the Ariane-4 launch vehicle on July 23 had become fully operational with all its payloads switched on and it had been successfully placed in its orbital position.



Satellite Data for Snow-melt Run-off Estimates

Large quantity of water on the planet earth lies in the form of snow and ice up in the mountains which can be considered as a frozen reservoir. Snow and ice accumulated during winter is released in the form of water into the rivers during summer when the demand for water is very high; water is also vital for hydro - electric power generation, irrigation and drinking. Important multipurpose projects like Bhakra in India, depend heavily (50 - 60%) on snow-melt run-off. Therefore, an accurate and timely information on the snow-cover conditions in the watershed areas enabling forecast of the volume of snow-melt run-off, can greatly help water resources managers in planning, budgeting and regulating the precious water resource. To forecast such run-off, information on terrain, snow-pack and meteorological parameters is required. But collection of such information is not always possible by ground-based systems due to rugged, hazardous and, in most cases, inaccessible terrain and sometimes due to the areas extending across international boundaries. Satellite remote sensing is therefore best suited for collecting information on the snow-cover under such situations. The Himalaya in the northern part of the Indian sub-continent, spread across 2,500 km, is the abode of some of the highest snow- covered peaks in the world. The average altitude of the Himalaya is about 6,000 m above mean sea level. The permanent snow fields at higher altitudes form the glaciers; some of the mightiest rivers in Asia, like the Ganga, Indus and Brahmaputra



IRS-IB imagery of snow-covered Himalaya

originate here. The Himalaya is actually a series of parallel ranges marked by jutting, snow-capped peaks, deeply eroded river gorges, and valleys, many of which were carved by the slowly creeping glaciers. The southern most range of the Himalaya is known as Siwalik Hills with a peak altitude of about 1,500 m. The middle range, the lesser Himalaya, varies in altitude from about 2,000 to 4,500 m. The northern most range of the mountains is the Great Himalaya.

Snow by virtue of its high reflectivity, is readily identified on any visible or near IR remotely-sensed image. Fresh snow has a very high reflectivity in the visible wavelengths which decreases as the snow ages. The reflectivity of snow is dependent on features like shape and size of snow crystals, liquid water content, impurities, depth of snow, surface roughness, etc. In addition, the sun angle influences the spectral reflectance to a large extent.

Data from Indian Remote Sensing Satellite (IRS), US Landsat and NOAA are being successfully used for mapping the extent of area covered by snow in the Himalaya basins. Studies on the use of microwave data, both active and passive, for deriving important aspects like volume of water stored in the snow-pack are in progress. Various snow types like dirty snow, fresh snow, snow in shadow and snow on different aspects of the terrain can be deprived from visible, near-IR and thermal-IR data by adopting digital analysis procedures. However, the area of snow-cover still remains the most important information readily amenable to analysis and acceptable as input for hydrological modelling.

Snow-cover area estimated from satellite data is primarily used in run-off modeling. The availability of forecasts of snow-melt run-off for the whole snow-melt season – the months of April, May and June, termed as "seasonal forecast" – at the beginning of the melt season are very useful for planning the strategy for utilising the water resources for that particular season. Forecast of snow-melt run-off for a few days for weeks at a time, termed as "short-term forecasts", is required for day-to-day decision making regarding reservoir operations.

The satellite data have been successfully used for small basins upto 5,000 sq.km. Digital interpretation with image analysis computer systems is being used extensively for mapping snow covered area in different basins/sub-basins of the Himalaya.

To model the run-off, two approaches are followed:

LANDSAT MSS image showing Beas and Parbati basins

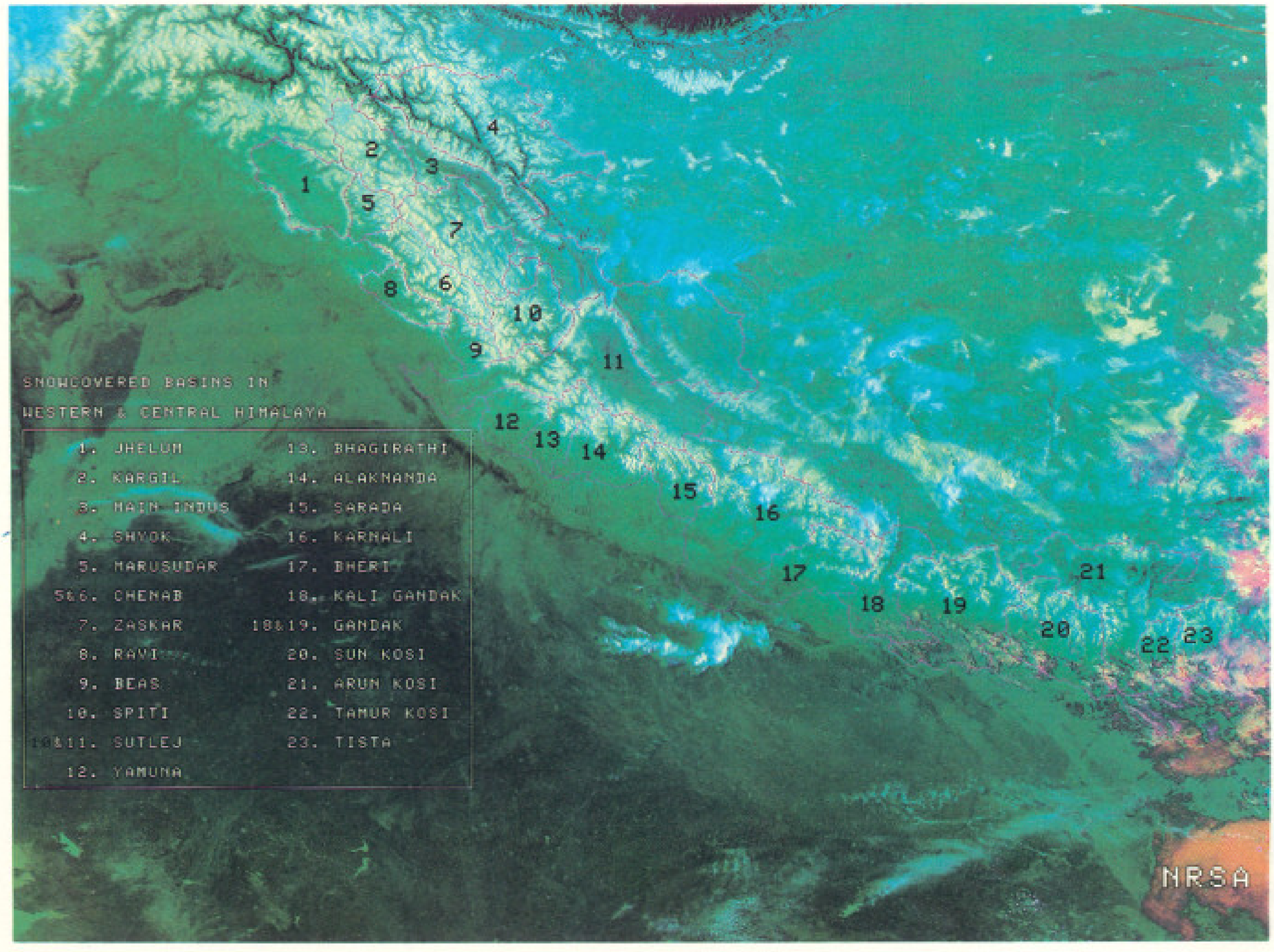
Classified image showing snow, transition and non-snow areas in Beas and Parbati basins.

i) statistical and graphical approach and ii) physical process-based approach. In the former, the variables influencing the snow-melt run-off process are related statistically and graphically with the snow- melt run-off. This method has been used for the Sutlej basin (47,000 sq.km) where the Bhakra-Nangal project is situated. The variables like area extent of snow-cover at the beginning of melt period (derived using remotely sensed data), total volume of water stored in the snow-pack (obtained from ground-based network as well as indirectly from monitoring the depletion of snow-cover through remote-sensing) and the total energy input during summer months (April, May & June) in the form of "accumulated degree- days" computed from daily maximum and minimum air temperatures, are related to the three months April-May-June snow-melt run-off inflows from the basin into the Bhakra reservoir. Since most of the energy absorption is through the surface area of the snow-pack, larger the area more the energy absorption and the resulting discharges, and vice-versa. The total volume of water stored in the snow-pack also influences the snow-melt run-off since more the water equivalent more is the melt water yield. The driving force for the melting process being the energy input, air temperature can be taken as the single most reliable index of such energy input. It almost completely reflects the effects of radiation, conduction, wind and humidity which influence the energy input to the snow-pack.

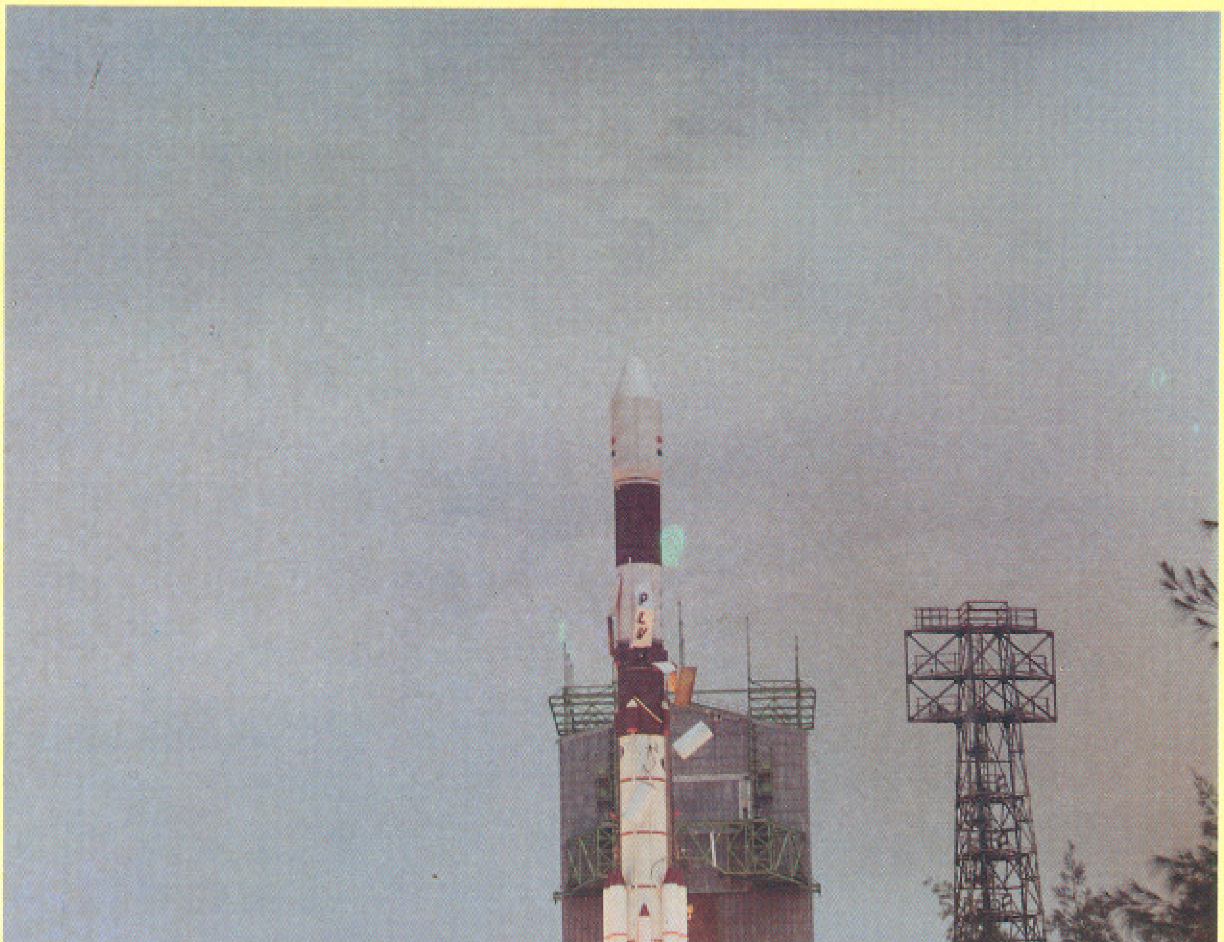
In the operational situations, it is not possible to get data on the water equivalent of the basin at the beginning of melt period, due to inaccessibility. A method of computing the basin water equivalent using remote sensing has now been successfully developed. The area extent of snow and its depletion is monitored through the melt season using satellite data and the rate of depletion is indicative of the snow water equivalent. The concept is that a thick snow-pack (with more water equivalent) starts depletion late and slowly compared to a thin snow-pack (less water equivalent) which starts depletion early and faster. The model developed based on this approach is being used to issue seasonal (April-May-June) forecasts of likely snow-melt run-off in Sutlej basin.

In physical process-based approach, the total melt water resulting from the snow-melt process on each day is computed. Since all this melt water may not result as discharge at the outlet of the basin on the same day, this quantity is distributed over a few days using recession co-efficient. Also, during the process of snow-melt resulting as discharge at the outlet, there are many losses that occur, like seepage, evaporation, etc. These losses are taken care of by introducing a bulk co-efficient called the run-off co-efficient. This approach has been adopted in the Martinec - Rango Snow-melt Run-off Model (SRM) which has been implemented in an operational mode to issue short term (7-day) forecasts of snow-melt run-off during March to July every year in the Beas basin (5000 sq.km) and Parbati sub- basin (1100 sq.km) in Himachal Pradesh.

The mapping and monitoring of snow-cover studies are proposed to be extended to the entire Himalaya. Attempts are also being made to understand the hydrology of the region including the influence of glaciers, hydrologically significant land cover/landuse etc., which will involve development of new techniques for integrating large amount of information (partly derived from satellite remote sensing and partly from conventional ground measurements). A long term continuous monitoring of snow-cover of the Himalaya is important for a better insight into the complex interacting processes and to determine the ecological consequences of global nature. Remote sensing satellites have an important role in this. ☐



NOAA - AVHRR imagery showing western and central Himalaya and 23 large basins where snow-cover monitoring is being done.



PSLV lift-off , Mobile Service Tower is seen in the background.


INSAT-2B VHRR VISIBLE 31-JULY-93 11:30
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