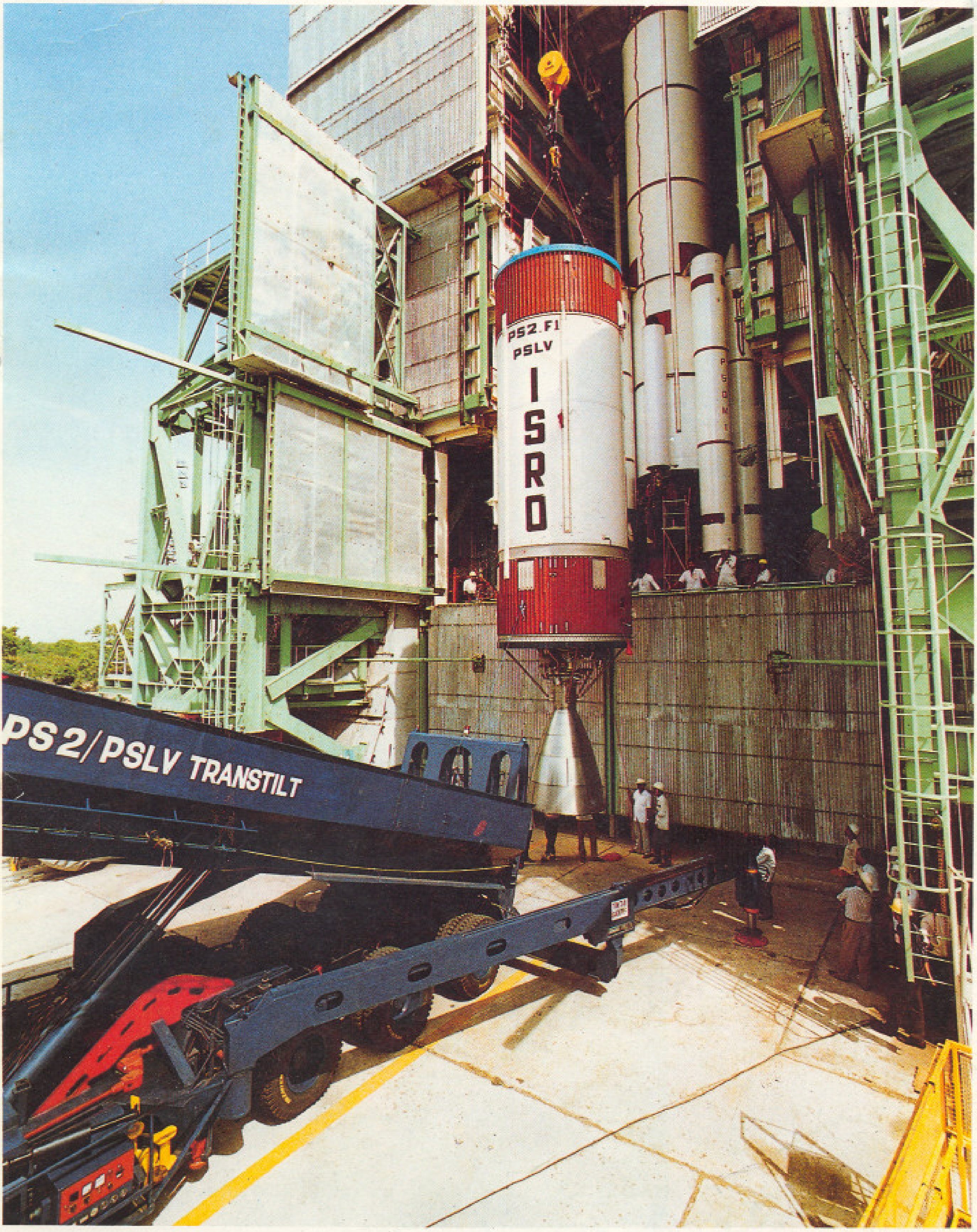
APRIL-JUNE, '93

SPACE india



INDIAN SPACE RESEARCH ORGANISATION

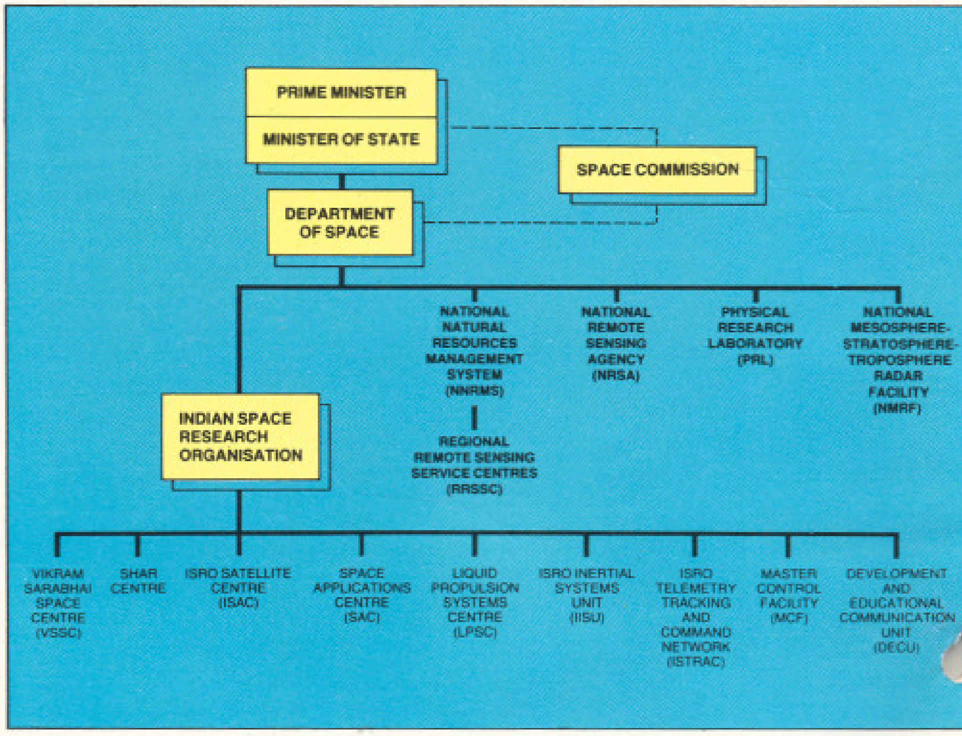
The Indian Space Programme

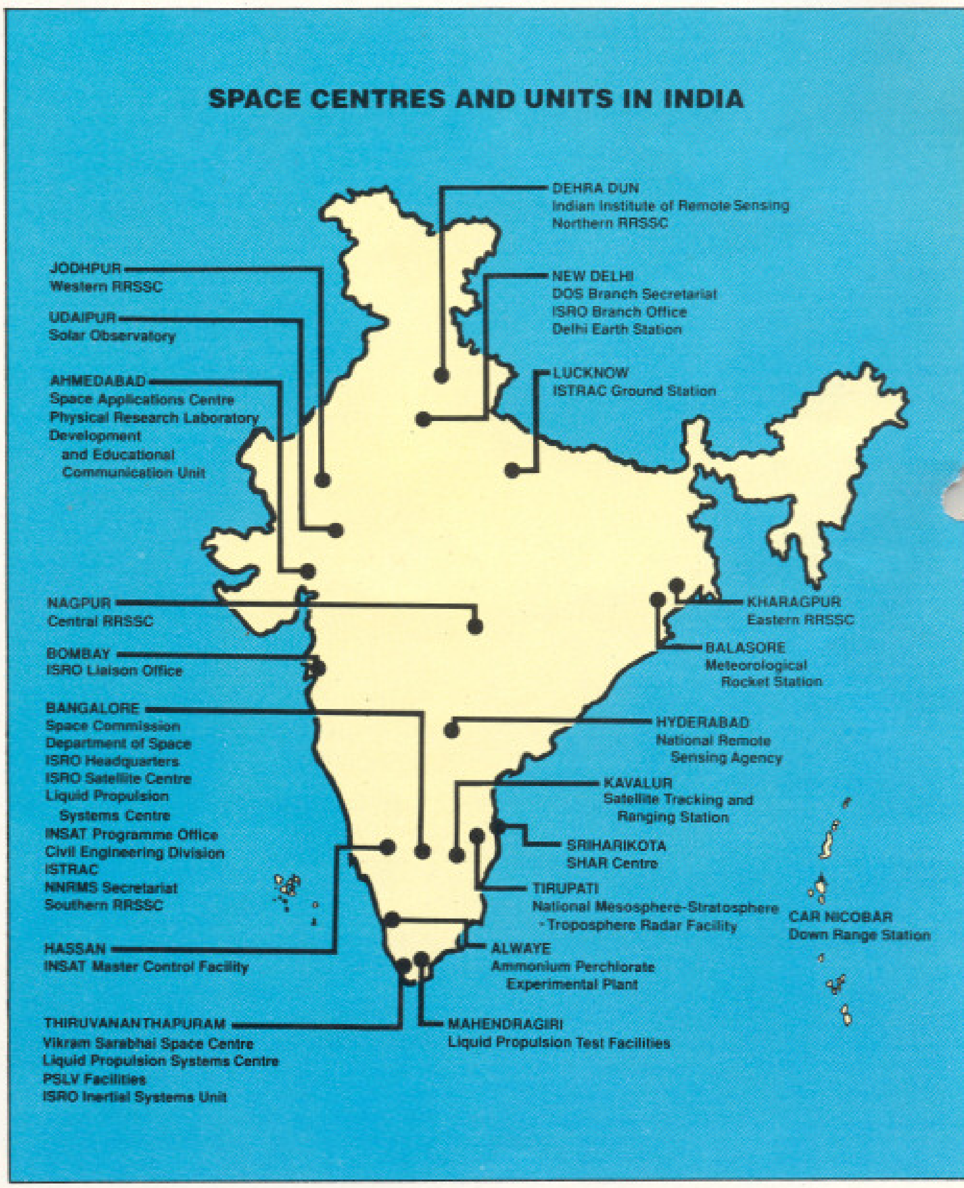
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science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

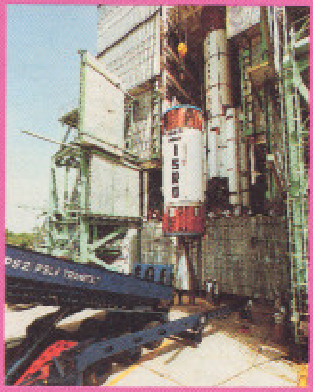
The Indian Space Programme is directed towards the goal of self-reliant use of space technology for national development, its main thrusts being: (a) satellite communications for various applications, (b) satellite remote sensing for resources survey and management, environmental monitoring and meteorological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

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

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







FRONT COVER

The liquid propulsion second stage of PSLV being lifted on to the MST

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Contents

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PSLV Launch — Focus Shifts to SHAR Launch Complex

The Sriharikota Range, popularly known as SHAR, is all set for the most important event — the first launch of Polar Satellite Launch Vehicle (PSLV) this year. The existence of elaborate infrastructure and up-to-date technical facilities, unique geographic location and the availability of a large unpopulated land mass, proximity to a large metropolis, Madras, make SHAR one of the ideal launch ranges in the world.

Starting with the launch of a 125 mm diameter sounding rocket way back in 1971, the launch facilities at this range have been augmented in consonance with the progress made by ISRO in rocketry. Over the last two decades, SHAR supported all the launches of ISRO's SLV-3 and ASLV, besides the routine launches of Rohini sounding rockets.

The major facilities of SHAR supporting the PSLV launch include:

— Propellant Production and Test Facilities

— Mobile Service Tower (MST)

— Umbilical Tower and Launch Pedestal

— Integration Facilities

— Propellant Storage, Transfer and Servicing Facilities

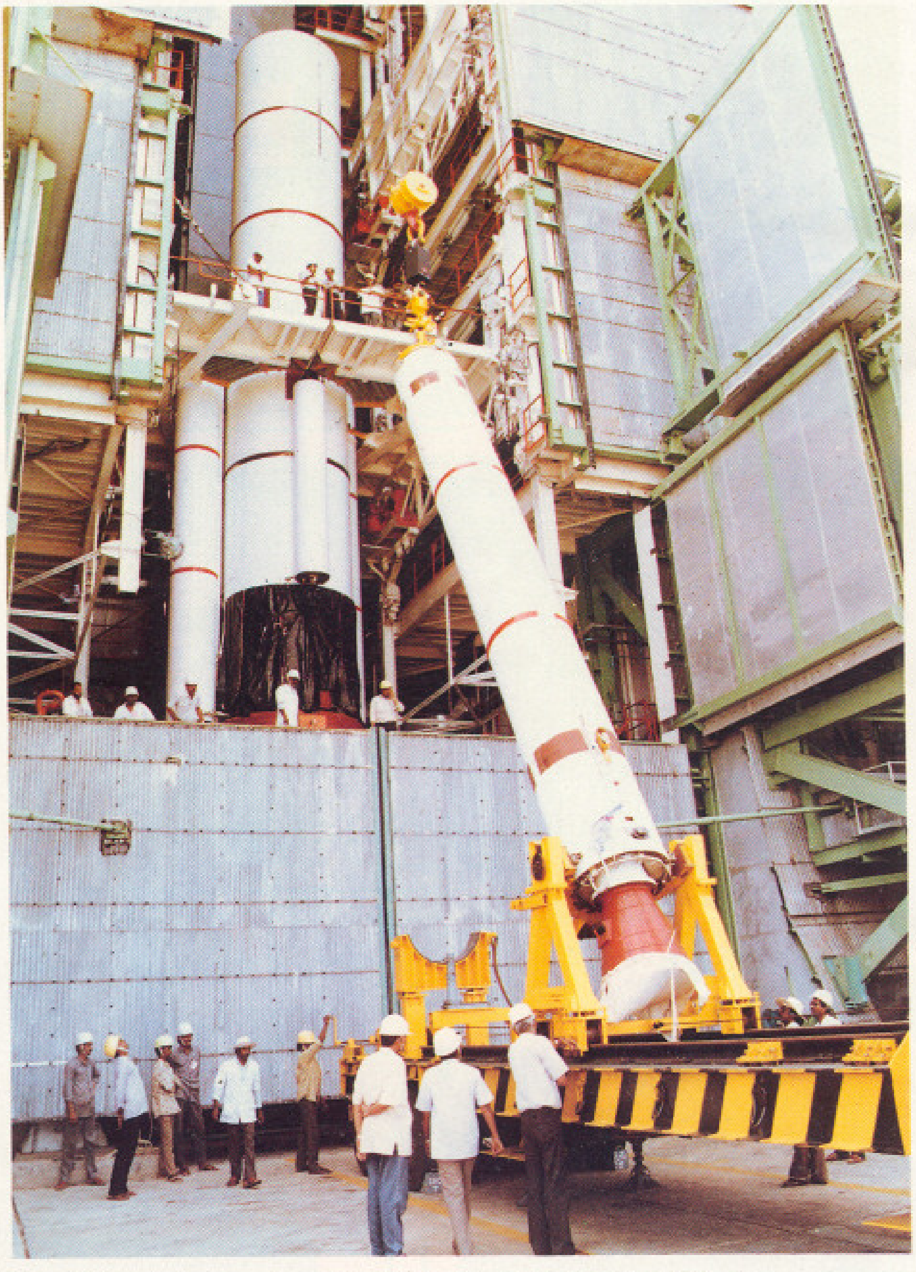
— Safety and Fire Fighting Systems

— Check-out Facilities

— Satellite Integration Facility

— Range Instrumentation System

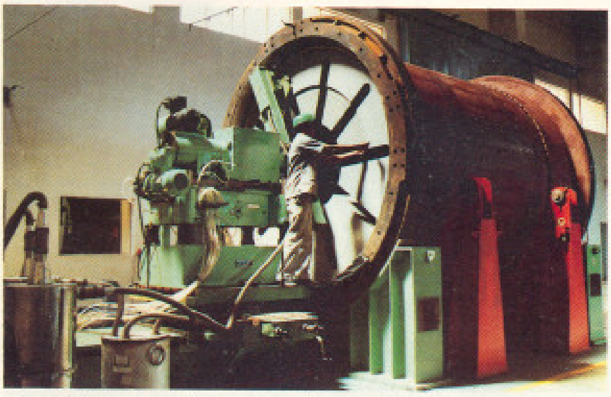
— Mission Control Centre



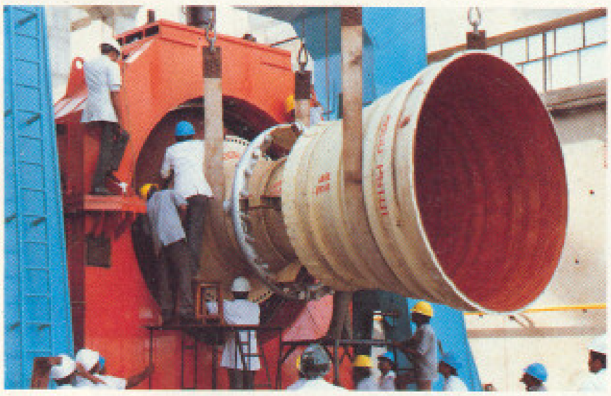
One of the strap-on motors being lifted for attaching with PS-1 stage

Propellant Production and Test Facilities

SHAR has set up several important production and test facilities for solid rocket motors of ISRO's launch vehicles including PSLV. The Solid Propellant Space Booster Plant (SPROB) processes composite solid propellant motors up to 2.8 m in diameter. The propellant consists of ammonium perchlorate as the oxidiser and Hydroxyl Terminated Poly Butadiene (HTPB) as the fuel with aluminium powder as an additive. For qualifying the solid motors, the



Propellant trimming operation at SPROB



PS-1 motor being prepared for Static test at STEX

Static Test and Evaluation Complex (STEX) at SHAR has capability to test motors both at ambient and simulated high altitude conditions. All the PSLV solid propellant motors have been qualified at STEX.

A view of the Mobile Service Tower (MST) — The loading platforms inside MST are also be seen

Mobile Service Tower (MST)

The MST, a mammoth steel structure is 76.5 metres tall and weighs 3000 tonnes. The launch vehicle and the umbilical tower are enclosed by the MST thus protecting the vehicle from severe weather. The MST is equipped with EOT cranes, pneumatic hoists, etc., to handle the various launch vehicle subsystems. MST has repositionable and fixed platforms providing access for assembly joints and other vehicle integration operations. An ultra-clean environment is maintained between elevations 41-metre and 62-metre. The MST has a 2,500 kg capacity elevator apart from the staircase to reach various working levels. The service lines for supply of compressed air, breathing air, water for fire fighting, eye wash, safety showers, etc., are distributed at various levels of the tower. Once the launch vehicle is fully integrated, the MST is moved to a distance of 180 metres before the launch. The movement is achieved by self-equipped traction system operating on hydraulic power.

Umbilical Tower (UT) and Launch Pedestal (LP)

The 52-metre Umbilical Tower is an open steel structure, permanently positioned adjacent to the Launch Pedestal. The tower accommodates various propellant and service fluid lines, check-out cables, air duct for satellite cooling and other associated systems. The UT is connected to the launch vehicle at various levels for servicing the latter with propellant service fluids such as helium, nitrogen, etc. The electrical umbilicals are also extended from this tower to the launch vehicle for check-out operations. Also a flexible umbilical supplies cooled air for satellite and Equipment Bay till lift-off.

PSLV rests over the centrally built annular ring on the Launch Pedestal (LP). Suitable cut-outs are provided in the ring and on the pedestal to let out the exhaust gases from the core and strap-on motors.

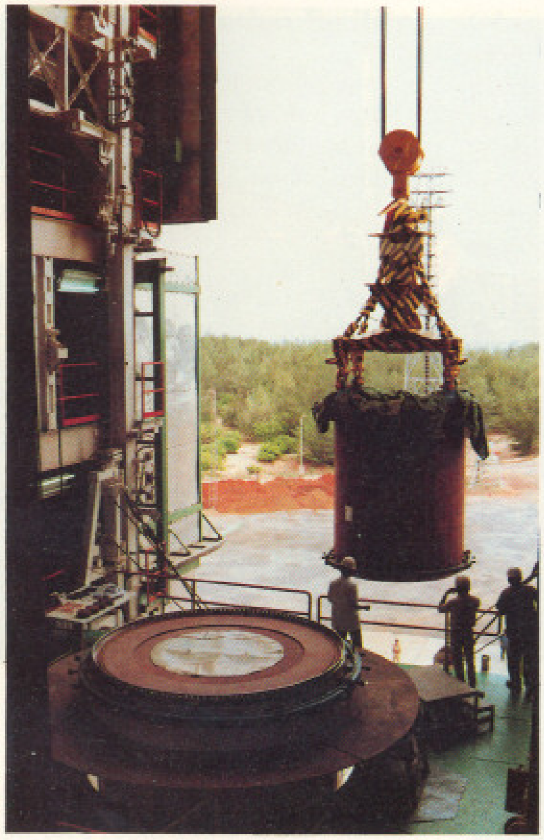
Integration Facilities

All operations on the rocket motors are carried out at the Solid Motor Preparation Facility (SMPF), consisting of a high-bay and a low-bay with EOT cranes and rooms for check-out, equipment, tools, etc. Sub-system Preparation Facility (SSPF) comprises high bay areas, airlock room and clean room along with safety control room. Adjoining this is a high pressure leak check facility for various control systems. The clean room has provisions such as conductive flooring, dike with stainless steel platform for positioning the satellite, trolley and a weighing platform. The satellite is filled with liquid propellants in this area prior to its movement to launch pad for mating with the launch vehicle.

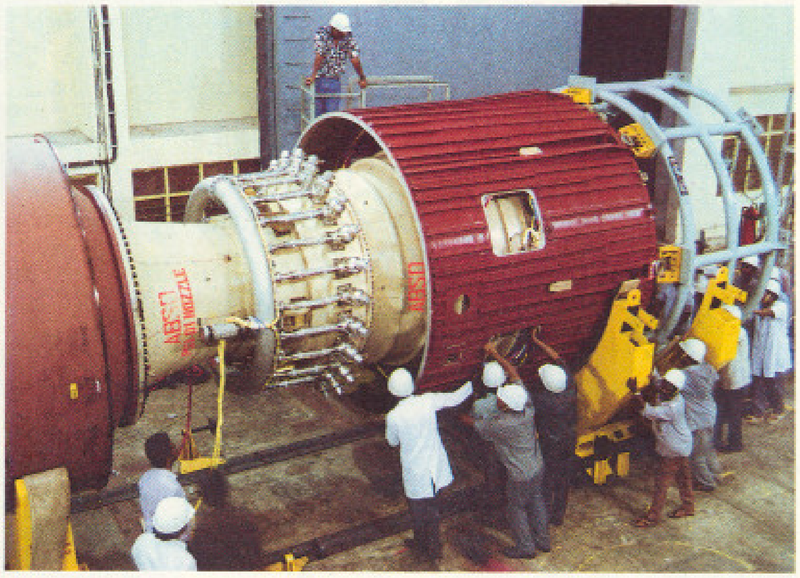
The Umbilical Tower with PSLV mock-up model

The liquid propulsion fourth stage ready for integration

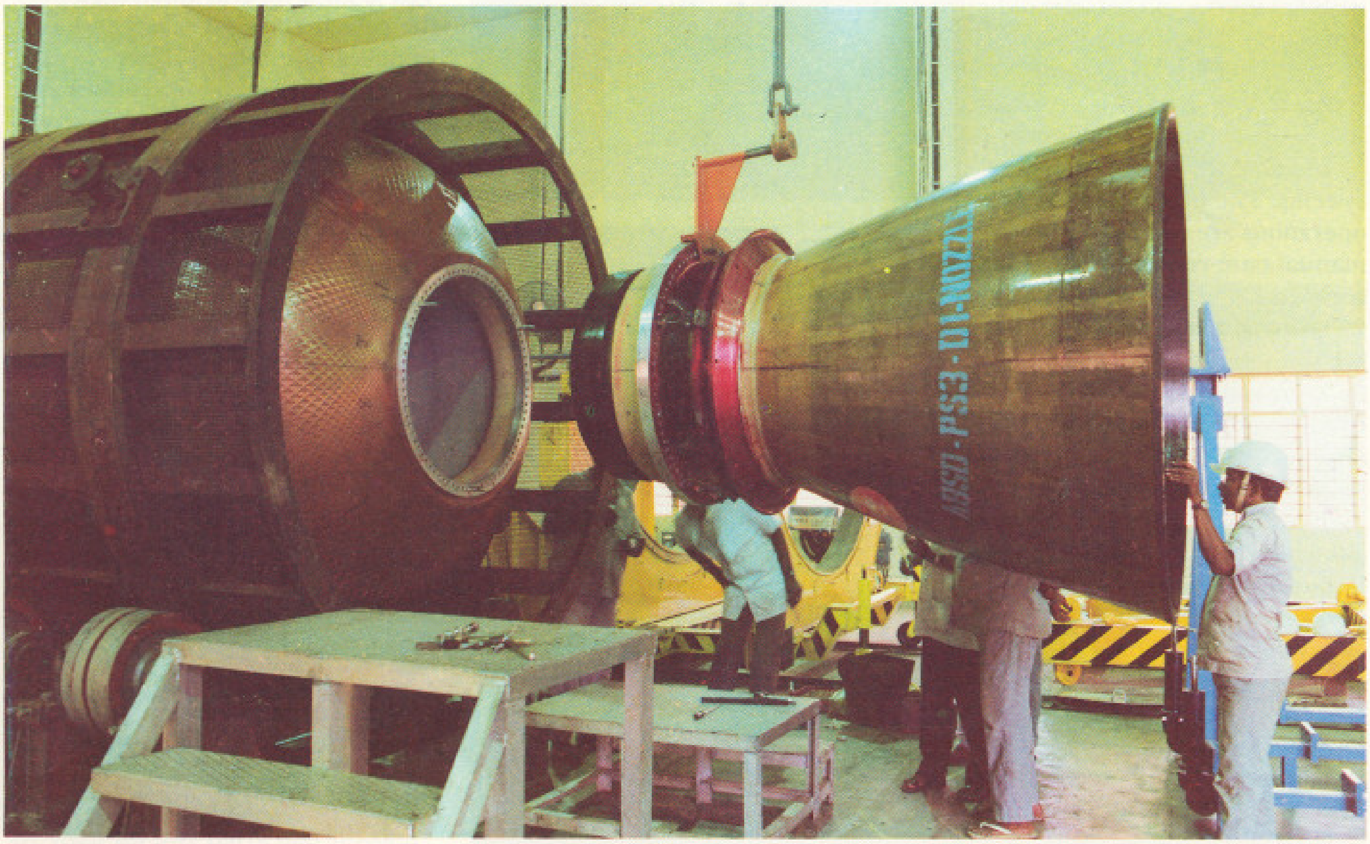
Lifting operation on nozzle end segment of the first stage motor



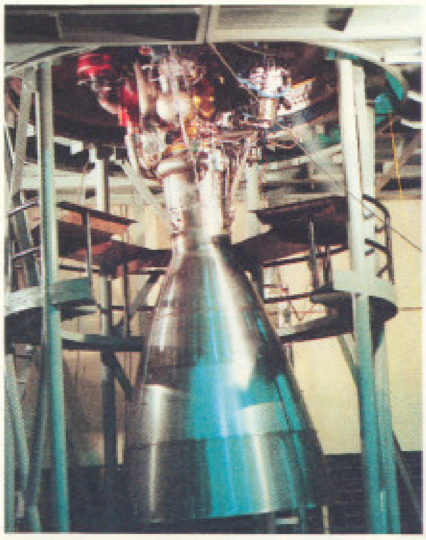
Middle end segment of the first stage being lifted for stacking on nozzle end segment



Base-shroud being assembled with PS-1 nozzle end segment



PS-3 motor assembly at Solid Motor Preparation Facility



PS-2 Engine at the Sub-system Preparation Facility

N_2O_4 tanker being interfaced with the fluid circuits

Propellant Storage, Transfer and Servicing Facilities

The liquid propellants, UDMH and N_2O_4 for the second stage and MMH and MON-3 for the fourth stage are transported to SHAR in mobile tankers and transferred into storage tanks positioned in a storage complex. The storage complex is built with safety features such as automatic sprinklers water jet monitors and fire hydrant systems. The propellant transfer operations are carried out in the manual-cum-remote mode from a command and control room about 200 metres away. The propellants are transferred to the PSLV stage tanks by redundant pumps, fluid circuits and command/control systems. A Gas Storage Facility located near the launch pad stores high pressure nitrogen and helium gas which are supplied to various terminal rooms and UT through permanently laid pipes. Two air-compressors supply breathing air and compressed air for operating the pneumatic hoist inside the clean room of MST and for operation of pneumatic tools in various integration and launch facilities. Pollution Monitoring Systems are deployed at all propellant transfer and handling areas including MST. Eye/face wash and emergency showers are installed at all propellant handling installations to dilute and wash off any propellant spills.

Check-out Facilities

Two dedicated check-out facilities have been established; Check-out Terminal Room (CTR) near the launch pad and Launch Control Centre (LCC) away from launch pad. These two are linked through optical fibres and shielded control cables. An automatic launch processing system has been installed for performing the overall check-out of the launch vehicle. The CTR is directly interfaced with the vehicle through cables and umbilical connectors. The propellant servicing operations are performed remotely from operator consoles located in LCC.

Check-out terminal room in the foreground of MST

Satellite Integration Facility

The satellite integration facilities include SP-1 facility located at the control centre, SP-2 facility as part of subsystems preparation facilities and SP-3 facility as part of MST.

All spacecraft for launch from SHAR are first taken to SP-1 facility which has three individual bays: high-bay, material air-lock bay and dynamic balancing room. The operations carried out in SP-1 include inspection of the spacecraft on arrival, functional/operational tests on subsystems, RCS system leak checks, solar panel deployment and illumination checks and dynamic balancing. Compatibility checks with the ground stations through RF and cable links are also carried out.

The SP-2 facility consists of a high-bay clean room, material air-lock room and a safety control room. The facility is used for RCS filling operations and is equipped with EOT cranes, nitrogen gas, compressed air, breathing air, etc., required for propellant charging operations. The satellite prior to propellant filling is also checked for its compatibility with payload adaptor of the launch vehicle.

The SP-3 facility has a clean room used for satellite assembly and integration with the launch vehicle. Cooled air is circulated inside the heatshield of the vehicle to keep the satellite within specified temperature limits. Monitoring of the satellite is done through umbilical lines and RF links between MST, SP-1 facility and Ground Telemetry Station.

Range Instrumentation Systems

The tracking network consists of three high precision and two medium precision C-band radars and one S-band radar. The long range precision monopulse radars operating in C-band and one radar operating in S-band (in skin mode) are used for any particular mission. Medium precision radars in C-band are also deployed whenever necessary. One high precision C-band radar is employed at Down Range Station located at Car Nicobar. All these radars are connected to the centralised computing facility through redundant data links. The data is processed in real-time for Range Safety.

Telemetry systems comprise ground stations operating both in S-band and in VHF band. The S-band station can receive and record simultaneously four carriers. The ground station is also equipped to provide Range and Range rate information.

The launch vehicle telecommand system operates in hot standby mode. It can be operated remotely by the Range Safety Officer by a single switch operation. The antenna systems are driven in computer designate mode from the Central Computing Facility.

Down Range Stations of ISRO Telemetry, Tracking and Command Network (ISTRAC), located at Mauritius, Thiruvananthapuram and Car Nicobar, support the

PCMC Radar antenna (top) and Instrumentation (bottom)

Telemetry station at SHAR

mission. A long range precision monopulse radar located at Mauritius provides the tracking information. The Down Range Stations located at Car Nicobar and Thiruvananthapuram also receive the telemetry and ranging data.

A number of medium power HF transreceivers are deployed at various locations to coordinate air and sea clearances for the launch. VHF transreceivers are used for mobile communications for safety, security and fire fighting. All the ground stations such as radars, telemetry and telecommand stations, launch complex, control centre, computers and other supporting stations are interlinked with multi-channel intercom system. Dedicated point-to-point communication links are also available between selected locations. A paging channel covers all the stations throughout the range for common announcements and central coordination. Dedicated data links connect various ground stations with mission computers. Critical links are provided with redundancy.

Range timing system generates and supplies standard timing information to all the ground stations and support facilities involved in the launch operations. Universal time synchronisation is achieved by monitoring standard time transmissions.

Closed Circuit TV (CCTV) system helps monitor integration, check-out and launch operations. Besides, a well equipped photographic facility, including high speed cameras, helps in documenting the gamut of activities of SHAR.

Mission Control Centre (MCC)

The Mission Control Centre is the focal point for real-time monitoring and control of launch operations. The functions of MCC are:

— to coordinate operations during vehicle integration and check- out phase,

— to monitor and control the progress of launch operations during the final countdown phase,

— to monitor vehicle systems, ground stations and other systems supporting the Launch operation,

A walkie-talkie set in use inside MST

— to conduct simulation exercises prior to launch count down,

— to authorise the launch.

Status/data from all the ground stations, vehicle and satellite are displayed at various consoles in MCC. Two computer systems work in hot redundant mode to process the data. The information is pre-formatted into defined pages for selection and monitoring at the consoles. The weather information from conventional weather observatory, Upper wind observatory and APT picture from NOAA satellite are displayed at the Mission Control Centre. All key personnel/experts involved in the decision making process occupy positions at the Control Centre during the count down period.

All the facilities established in SHAR over the years will soon be put to their ultimate test with the launch of PSLV. □

Mission Control Centre

CCTV Control Room

SITVC and Reaction control thruster along with PS-1 nozzle end segment at the Solid Motor Preparation Facility

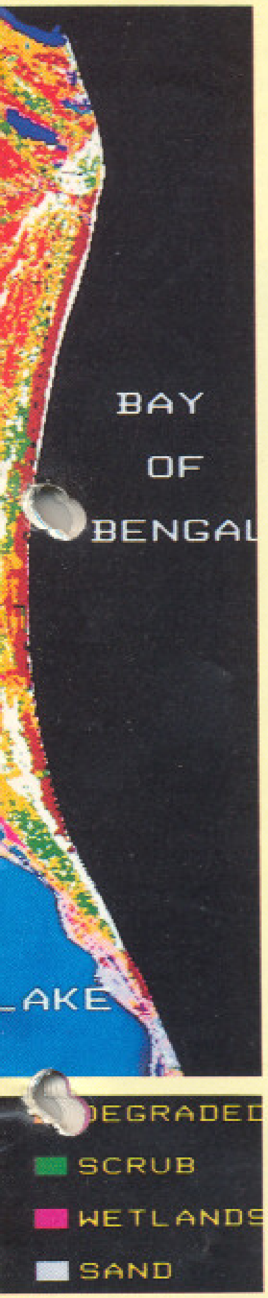
Range safety consoles

HERBARIUM AT

The scenery of Sriharikota is varied and picturesque with extensive jungles honeycombed with plantations of eucalyptus, casuarina and cashew and numerous groves of coconut, palmyrah and canebrakes. The varied ecological habitats, sand beach, sand dunes, salt-marsh, lagoon, stream courses, water lenses, low lying areas, etc., on the island harbours rich and valued floristic wealth.

The Sriharikota island, with an area of 180 sq km, is a barrier island sandwiched between the Pulicat lake and the Bay of Bengal. It is about 44 km long in the north-south direction and about 7.8 km broad at its widest section. The maximum elevation is 10 m above mean sea level. Two streams, Peddavagu and Chinnavagu, flow parallel to each other in the middle of the island in the north-south direction. The island is just a low ridge of sand with marine and eolian deposits and is almost flat. The climate is tempered by the moderating influence of the sea breeze from the Bay of Bengal and the Pulicat lake. Though the island experiences both the monsoons, the principal rainfall is due to the north-east monsoon during the winter. The average annual rainfall is about 1200 mm, being very heavy from October to December and moderate between July and September.

T SRIHARIKOTA



During 1977-82, ISRO had sponsored a botanical study of Sriharikota island in coordination with the scientists of Sri Venkateswara University. The study was made with a view to setting up a Herbarium and compiling a report on the flora of the island. During 1988-89, the SHAR Herbarium started off with more than 400 species belonging to 110 families. The vegetation on the island has been classified into (1) dry evergreen forest (2) scrubs (3) plantations (4) sea shore vegetation and (5) aquatic vegetation. Close-up photographs of many species have been captured and compiled under the study.

The 428 species collected in the Sriharikota Herbarium include: a) Dicotyledones (Polypetalae - 175, Gamopetalae - 118, Monochlamydae - 55); b) Monocotyledones (Sedges -16, Grasses - 24, Others - 37) and c) Pteridophytes - 3. Details of each of the species, from Abrus precatorious through Zizyphus Jujuba (mauritiana) have been catalogued along with a specimen each. Many of these species are very rare and some of them are understood to have been located only in the Sriharikota island.

The herbarium is a useful library for students and researchers interested in the study of the flora of Sriharikota island.

Sounding Rockets Launched for Ionospheric Investigations

Two RH-560 sounding rockets were launched from Sriharikota, on February 19, 1993 for carrying out in-situ measurements of neutral winds, electric fields, neutral temperatures, ion and neutral composition, electron densities, electron temperatures and electron density irregularities. The launches were conducted under conditions favourable for generation of Spread-F. Four Barium blobs were released by the first rocket at 1845 hrs in the height region of 180-300 km and the clouds formed were photographed simultaneously from three ground-based camera stations located at Kalpakkam, Kavali and Gudivada. The second rocket, launched within 30 minutes of the first, carried a mass spectrometer developed jointly by India and Russia for obtaining data on ion and neutral composition, and a high frequency Langmuir probe for measurements of plasma density and irregularities. The second rocket reached an altitude of 290 km.

RH-560 Rocket with the Payload ready for lift-off

The earth's ionosphere is classified into different regions; D-region (60-90 km), E-region (90-150 km) and F-region (150 km and beyond) in the order of increasing electron and ion densities. The maximum plasma density lies in the F-region beyond which the densities decrease monotonically. The electron and ion density distribution is not always smooth. It is replete with small and large scale structures both in the vertical and in the east-west directions. The scale sizes of these structures vary from a few metres to few hundred kilometres. While irregular structures are seen all through day and night in the E-region over the equator, their generation in the F-region is restricted to evening and night-times. The presence of these irregularities affect the HF radio communication as well as the satellite links.

The F-region irregularities in the equatorial region are known as Equatorial Spread-F (ESF). Though discovered more than five decades ago, the various manifestations of ESF remain enigmatic even today. Ionisation hole or a plasma bubble is one such manifestation. In spite of the studies on ESF in the recent years made through systematic coordinated measurements, development of new theories and nonlinear numerical simulation methods, certain basic questions like what controls the triggering of the phenomenon — under seemingly identical conditions ESF gets triggered on one day and is totally absent on another day—remain unanswered.

The sounding rocket experiments conducted on February 19, 1993 were to quantitatively evaluate the role of the triggering mechanisms, especially the neutral dynamics through simultaneous measurements of all the relevant parameters.

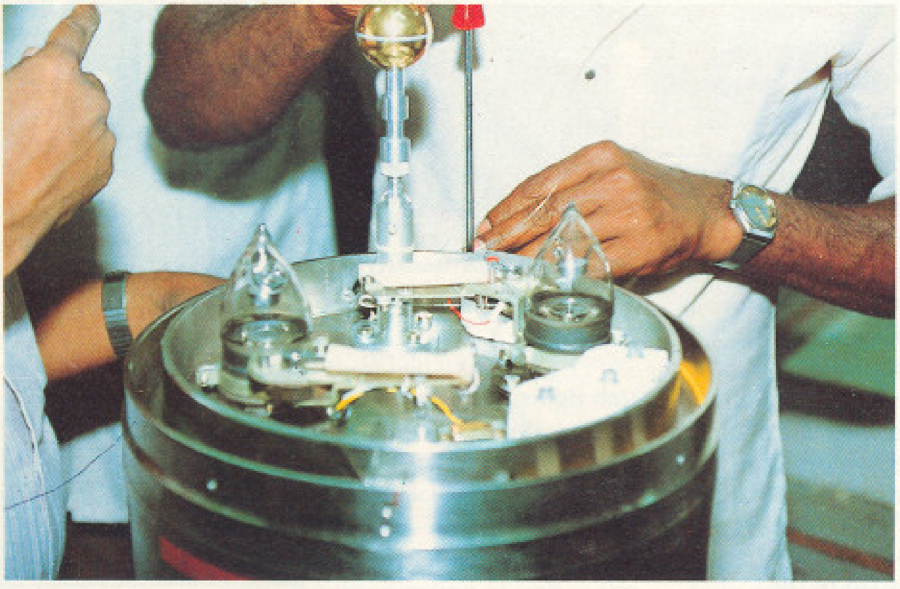
The rocket experiments provided the altitude profiles of the atmospheric/ionospheric parameters. To obtain the temporal variability of the atmospheric system, a set of complementary experiments was carried out a few days prior to the rocket flights. Several ground-based systems like ionosonde, magnetometers, HF doppler radar, MST radar in coherent ionospheric mode, VHF and UHF scintillation receivers and optical experiments like Dayglow photometer, all-sky imaging Fabry-Perot spectrometer, and all-sky imaging camera, were used for the campaign. Based on the data collected by these complementary experiments, the onset of ESF was predicted well before the occurrence of the phenomenon. The accuracy of prediction was demonstrated when ESF got triggered at 1915 hrs coinciding with the launches. Incidentally this happened to be one of the strongest events in that period. The camera stations covered the cloud releases successfully and the instrumented payloads functioned well.

Another RH-560 rocket was launched from SHAR on April 19, 1993 at 1120 hours carrying RF resonance cone payload of the German Space Agency (DLR) for measuring electron density and

The Rocket payload under vibration test

RH-560 lift-off and the release of multiple Barium blobs, as a part of the 'Ionisation hole' experiment electron temperature and a Langmuir Probe for measuring the plasma parameters in azimuthal and vertical directions. The objective of this ISRO-DLR rocket experiment was to investigate the electrodynamics of low latitude ionosphere over SHAR between the altitude regions of 85 - 320 km during day time of summer season and low solar activity period. The previous flight in this series had been conducted on May 4, 1987 which enabled comparison between two sets of measurements. □

ISRO-DLR Experiment for study of day-time equatorial F-region with deployable booms



Mass spectrometer and langumir probe payloads being integrated with RH-560 Rocket nose-cone for ionisation hole experiment

INSAT-2B

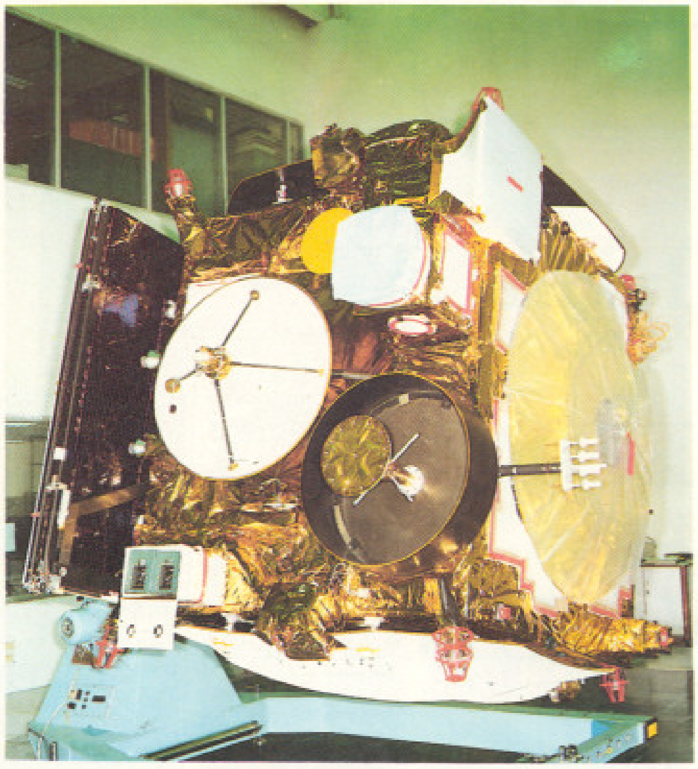
READY FOR LAUNCH

INSAT-2B, the second of the multipurpose INSAT-2 series of satellites, is now ready for its launch by an Ariane vehicle from Kourou, French Guyana. It was air-lifted from Bangalore on May 21, 1993. The first satellite in this series, INSAT-2A, launched on July 10, 1992, is performing well since its commissioning in August 1992.

INSAT-2B will be launched into a geostationary transfer orbit with a perigee of 200 km and an apogee of 35,876 km by the Ariane launch vehicle. A series of orbit and attitude manoeuvres will be conducted on the satellite before it is positioned at 93.5° East longitude in the geostationary orbit. All these and other subsequent operations on the satellite will be carried out by the Master Control Facility (MCF) at

Hassan in Karnataka. INTELSAT ground stations at Perth (Australia), Fucino (Italy) and Clarksburg (USA) provide TTC support during the initial phase of the mission.

Parked in the geostationary orbit, INSAT-2B, together with INSAT-2A and INSAT-1D (launched in June 1990), will augment significantly the INSAT space segment capacity for telecommunication, direct TV broadcasting and nationwide TV distribution, radio networking, meteorological observation and data relay, etc. □



INSAT-2B Spacecraft

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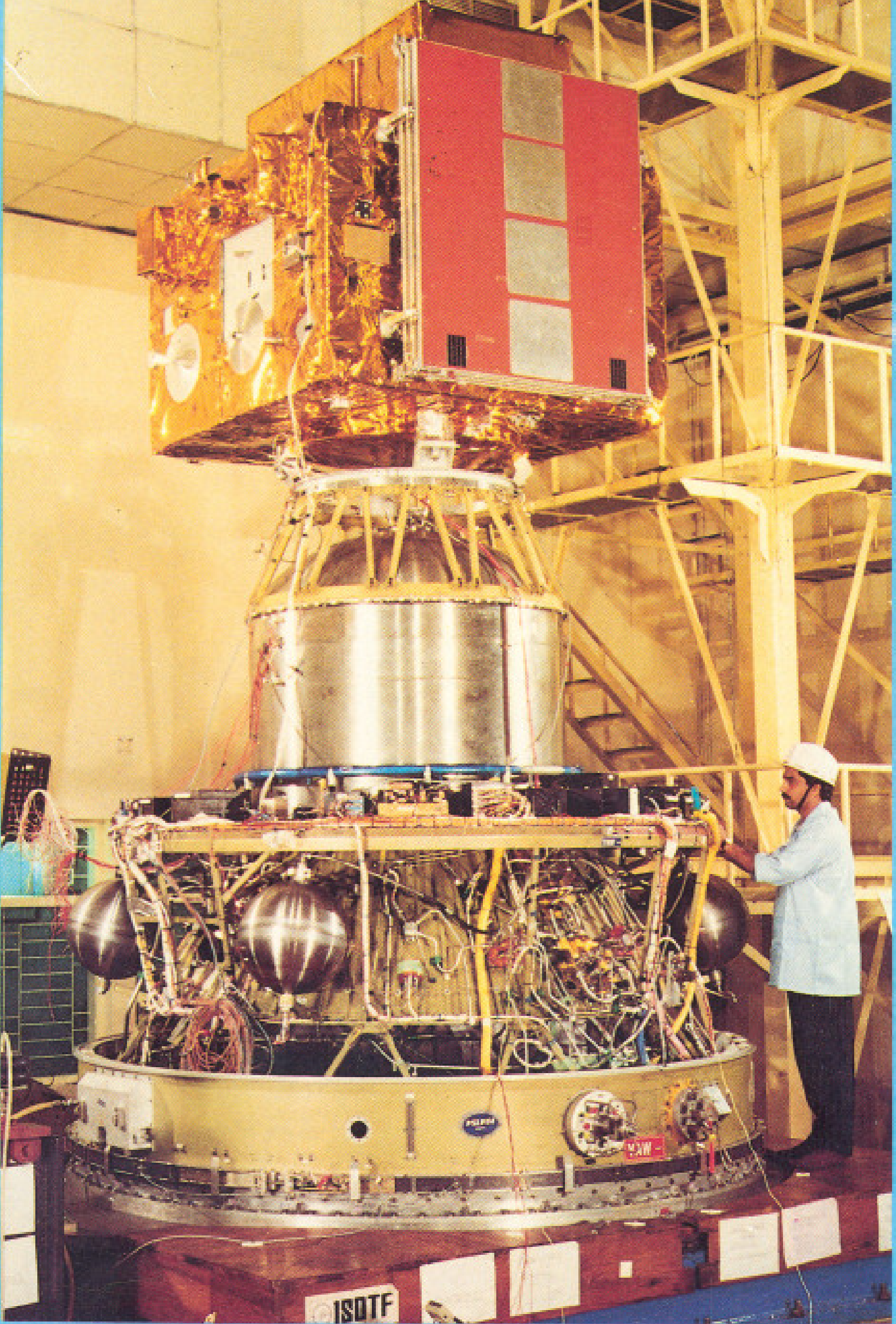
INSAT-2B SUCCESSFULLY LAUNCHED ON JULY 23, 1993



Combined structural test on IRS-1B along with PSLV fourth stage and Equipment bay

Some of the flora in Sriharikota