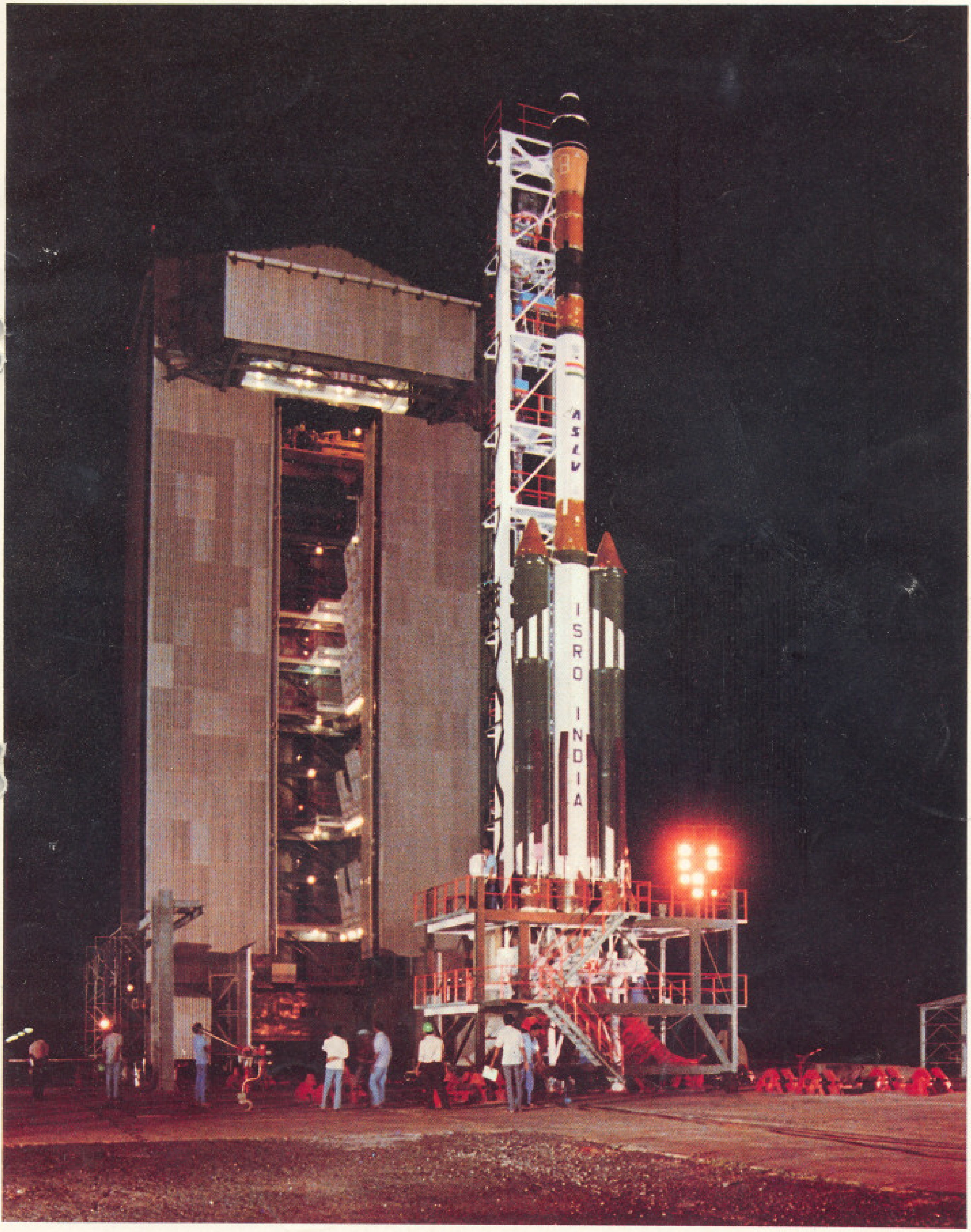
SPACE india

APRIL-JUNE, 1992



INDIAN SPACE RESEARCH ORGANISATION

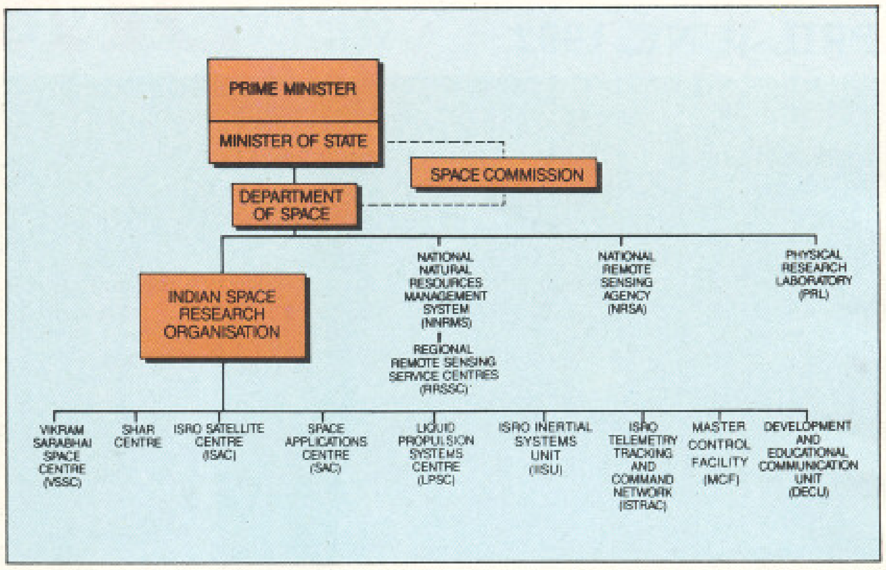
The Indian Space Programme

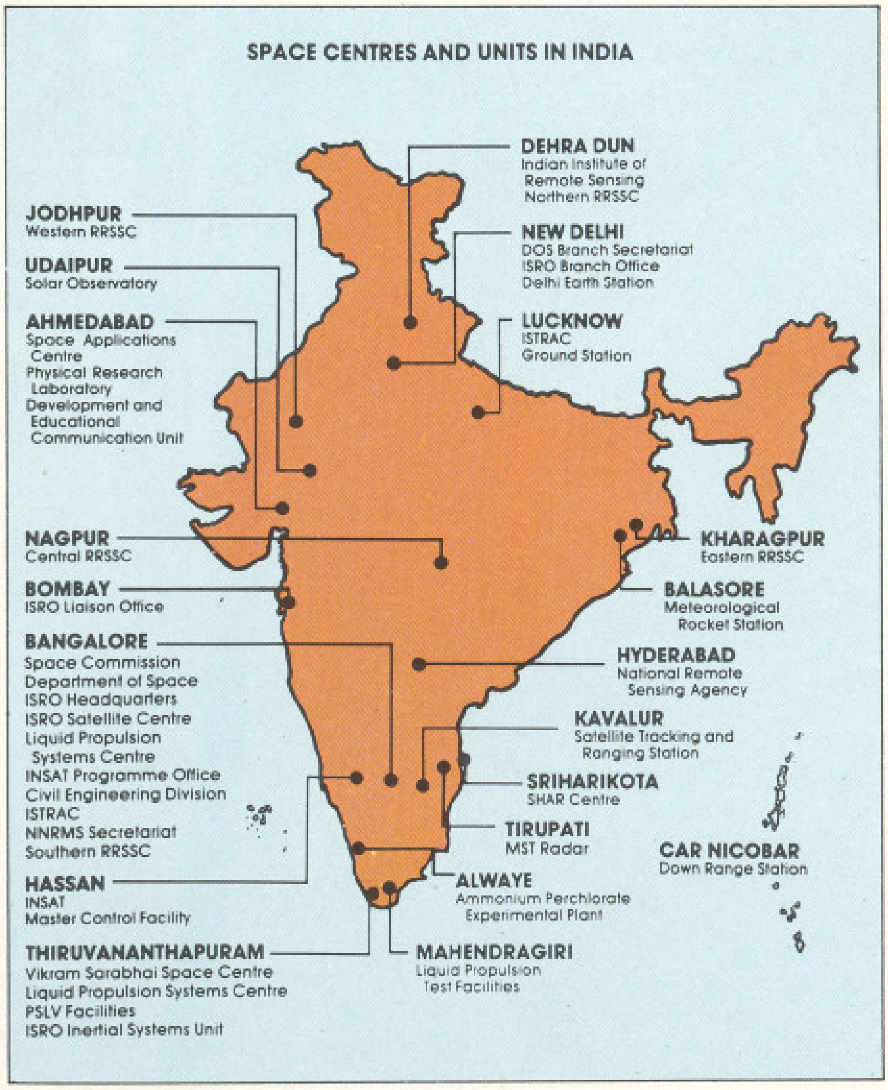
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science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

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

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

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





FRONT COVER
ASLV-D3 on the launch pad

EDITORS
S.Krishnamurthy
Manoranjan Rao

EDITORIAL ASSISTANCE
S.K. Dutta

PRODUCTION ASSISTANCE
B. Chandrasekhar

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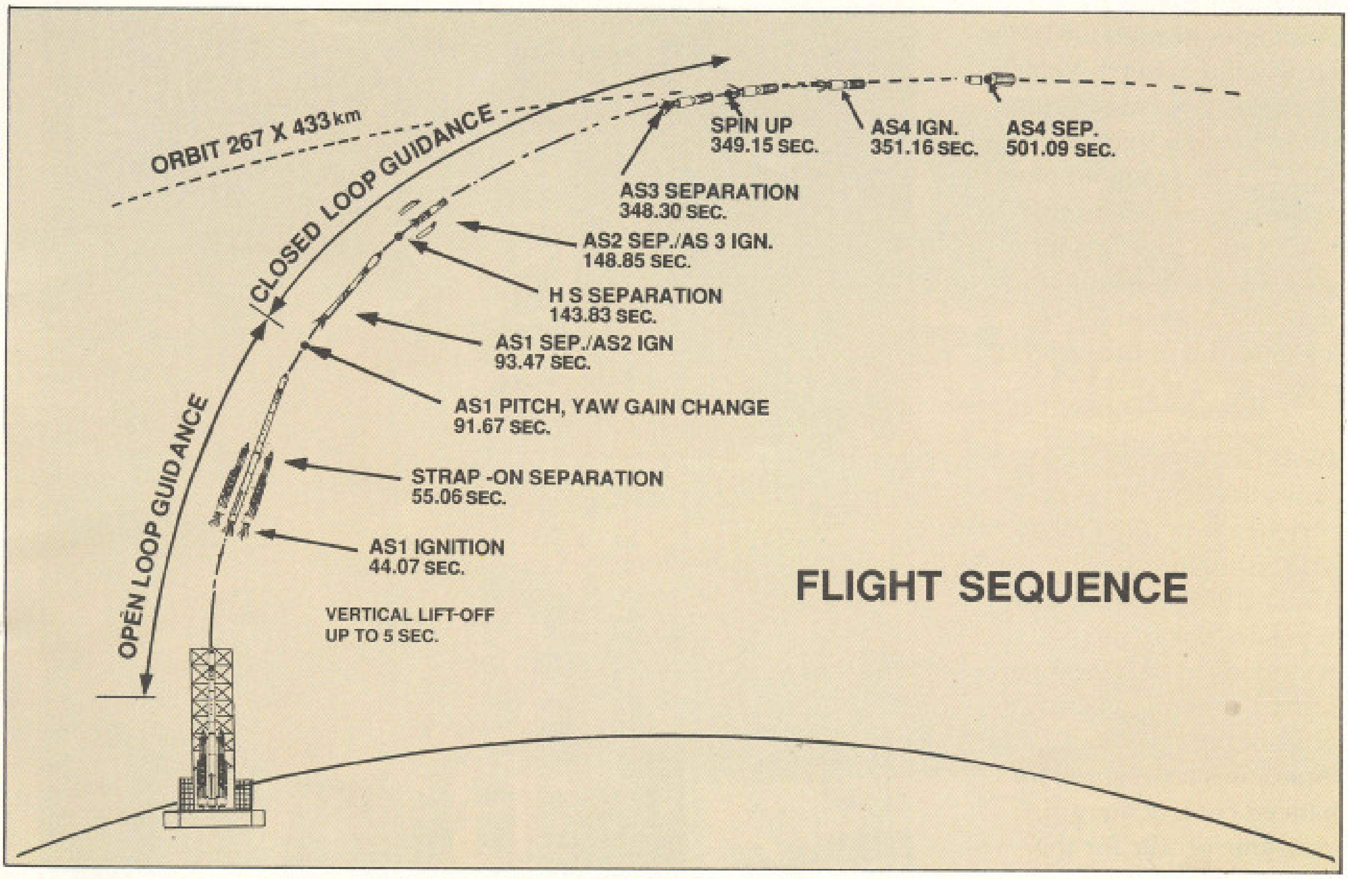
ASLV Launch Successful

The successful launch of the Augmented Satellite Launch Vehicle (ASLV), from Sriharikota Range (SHAR Centre) on the early morning of May 20, 1992, is a major achievement for the Indian Space Programme. This third development flight (ASLV-D3) of the launch vehicle successfully placed the 106 kg SROSS-C (Stretched Rohini Satellite Series) satellite into a near-earth orbit of 267 km perigee and 433 km apogee.

ASLV-D3 took off exactly at 0600 hours IST with the simultaneous ignition of the two strap-on boosters. 44 seconds later the first stage core motor ignition was commanded by the on-board Real-Time Decision (RTD) system. The strap-on boosters separated at 55 seconds. The first stage separation and ignition of the second stage were commanded simultaneously at 96 seconds after lift-off by the RTD system and the Closed Loop Guidance (CLG) system was active from then on. The heatshield was jettisoned at the predetermined altitude of 120 km at 144 seconds after the vehicle had cleared the dense atmosphere.

The lift-off



The second stage separation and third stage ignition occurred 179 seconds after lift-off.

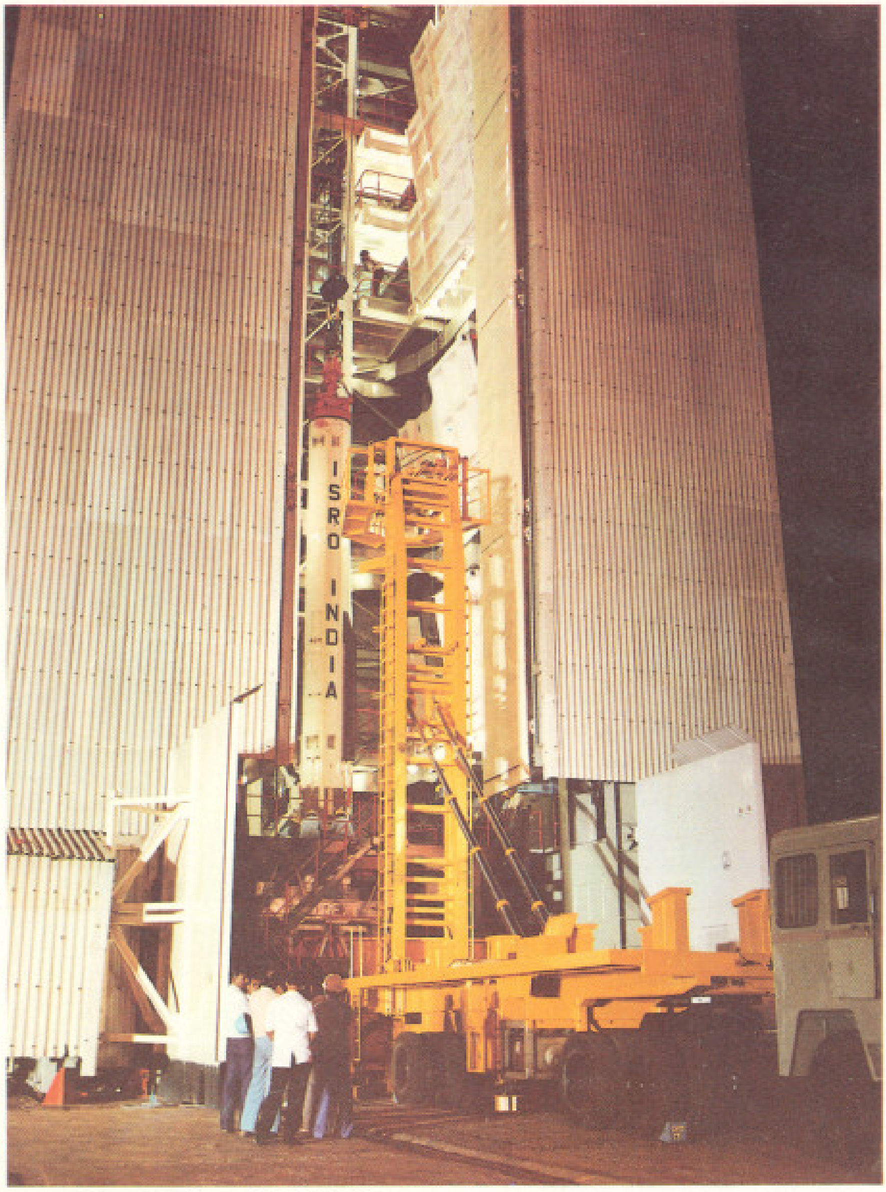
The burn out of the third stage at 204 seconds was followed by a long coasting phase. The closed loop guidance system functioned very well till the separation of the third stage at 349 seconds as planned. The fourth stage, along with the satellite, was spun up and the fourth stage ignited at 352 seconds. Separation of the SROSS-C satellite from the spent fourth stage took place about 500 seconds after lift-off.

The flight events were monitored using the telemetry and tracking stations located at Sriharikota, Thiruvananthapuram and Car Nicobar.

The successful launch of the five-stage, solid propellant, ASLV-D3 has demonstrated ISRO's mastery over a number

The mobile service structure being moved out of important advanced technologies needed for India's Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV). The design employed a number of new technology elements such as strap-on staging, closed loop guidance system, bulbous metallic heatshield and onboard RTD system.

ASLV-D3 incorporated several modifications based on the experience from the first two unsuccessful flights, conducted in March 1987 and July 1988. Two passive fins in pitch plane were added for the first stage to improve the aerodynamic stability of the vehicle. Digital autopilot was redesigned for enhanced control margin. Thrust-time profile for the strap-on stage was modified to reduce maximum dynamic pressure. ASLV-D3 used the indigenously developed Hydroxyl Terminated Poly Butadine (HTPB) based propellants for its strap-on, first and second stages. The third and fourth stages used High Energy Fuel-20 propellant. Modifications were also carried out on the vehicle structure to enable it to withstand enhanced loads during the flight. Augmentation of the control power plants for strap-on and core stages and introduction of Real-Time Decision (RTD) system for flight sequencing were the other major modifications incorporated in the ASLV-D3. The successful flight of the ASLV-D3 vindicated not only the findings of the earlier failure analysis committee but also the efficacy of the modifications and improvements described above.



Vertical integration of ASLV-D3

S-band Telemetry Antenna

Real time computer system

ASLV Block House

Vikram Sarabhai Space Centre (VSSC) at Thiruvananthapuram, the lead centre for launch vehicles in ISRO, was responsible for the design, development, integration and flight testing of ASLV. Liquid Propulsion Systems Centre (LPSC) at Thiruvananthapuram was responsible for the design, development and realisation of all the control power plants. The inertial navigation systems and the rate gyro package were designed and fabricated at the ISRO Inertial Systems Unit (IISU), Thiruvananthapuram. SHAR Centre was responsible for casting of some of the rocket motors, static testing of the motors besides providing launch facilities and actually conducting the launch. ISRO Telemetry, Tracking and Command Network (ISTRAC) provided the necessary TTC support. The SROSS-C satellite mission operations were carried out by ISTRAC through its Spacecraft Control Centre at Bangalore and the network stations at Bangalore, Lucknow and Mauritius.

The SROSS-C satellite carried two payloads, namely, (i) Retarding Potential Analyser (RPA) designed by the National Physical Laboratory (NPL) to investigate the characteristics of the equatorial and low latitude ionosphere and thermosphere, and (ii) Gamma Ray Burst (GRB) experiment developed at ISRO Satellite Centre for detecting celestial gamma ray bursts in the 20-3000 keV energy range.

The success of ASLV-D3 is a landmark in India's efforts to acquire indigenous capability in launch vehicle technology. It is also an important step towards development of operational launch vehicles for the Indian space programme whose main objective is to provide operational space services to the nation in communication and remote sensing. □

ASLV Salient Features

Lift-off weight	: 41.7 tonne
Height	: 23.8 metre
Payload	: 106 kg.
Orbit (nominal)	: 475 km Circular; Inclination: 45.4 deg.
Heatshield Diameter	: 1 metre

Stages

	Stage-0 (2 Strap-ons)	Stage-1	Stage-2	Stage-3	Stage-4
Length (m)	10.7	10.2	6.37	2.3	1.4
Diameter (mm)	1000	1000	800	800	650
Max. Thrust (kN)	645	662	269	89	32
Action Time (s)	47	48	39	47	33
Weight (kg)	11600 (x2)	11800	4400	1750	510
Control System	SITVC & Bipro-pellant RCS	SITVC & Monopro-pellant RCS	Biprope-llant RCS	Mono-pro-pellant RCS	Spin stabilised
Propellant	HTPB	HTPB	HTPB	HEF-20	HEF-20

The ASLV Programme - Some Challenges

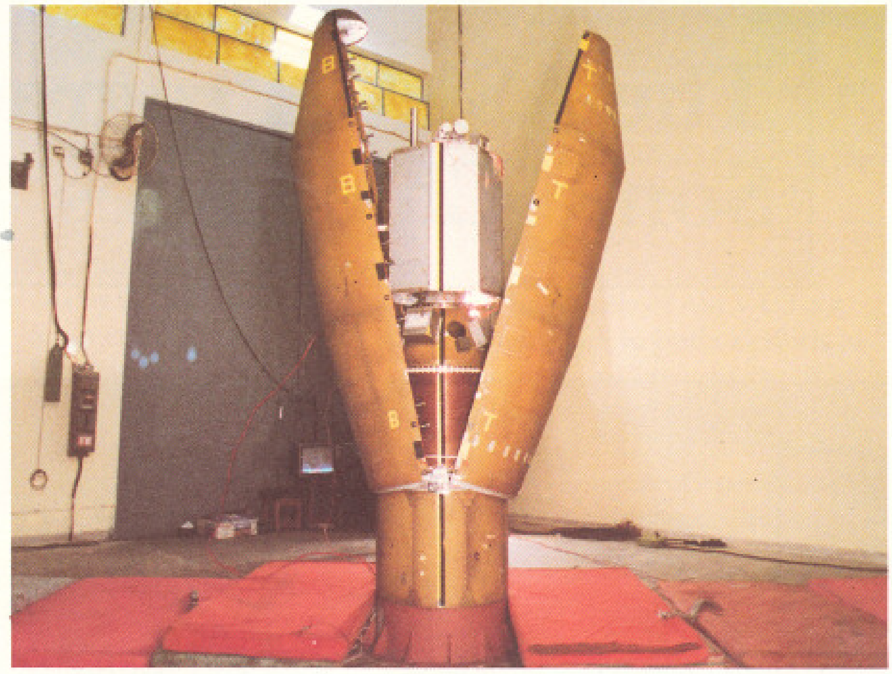
ASLV sub-assemblies

The ASLV programme was originally conceived with the objective of developing a launch vehicle for low earth orbit missions in the fields of space sciences, space technologies and space applications. Further, it was also envisaged that some of the new technologies validated by flight-tests would feed directly into the future launch vehicles of ISRO, viz. PSLV and GSLV. With these clearly specified goals, the ASLV programme had to be steered through a technologically challenging terrain! Some of these challenges and the steps taken to overcome them are described briefly below.

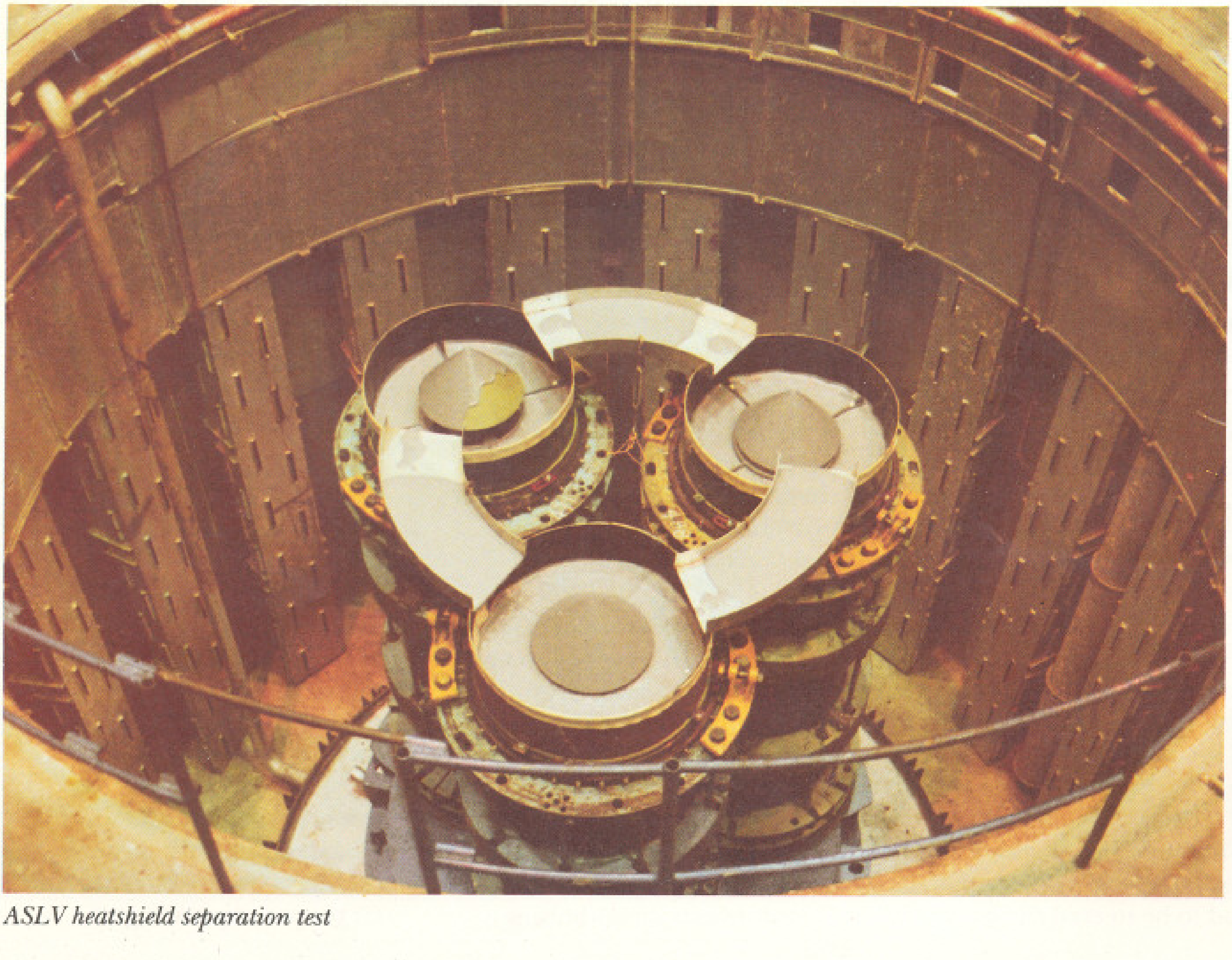
* The original mandate given to the ASLV project was to maximise utilisation of systems and subsystems which had already been flown on SLV-3, the first generation launch vehicle of ISRO. This did result in imposing certain constraints on optimising the configuration of ASLV.

Controllability of a vehicle which uses solid propulsion modules is critical, especially during the stage transitions. In ASLV, this problem was compounded by the fact that certain critical operations had to be carried out during the period in which the dynamic pressure and wind loads are high. All these problems were overcome by (i) proper sequencing of events (ii) incorporation of a double hump type of thrust-time curves for the strap-ons and (iii) incorporation of Real Time Decision (RTD) systems.

* In order to ensure collisions-less and clean separation of stages, extensive theoretical modelling of separation dynamics and a series of ground tests were carried out. It is usually said that each separation or jettisoning or even ignition event is like a rebirth for a launch vehicle. ASLV-D3 had six solid propulsion modules of which four had to be air-lit! And in ASLV, there were five separation and one heatshield jettisoning events. All the ignition, separation and



Triple casting of ASLV motors



ASLV heatshield separation test

Mission Control Centre

jettisoning systems performed flawlessly in the ASLV-D3.

* ASLV had as many as eight control power plants of different types; the Secondary Injection Thrust Vector Control, Bipropellant Reaction Control and Monopropellant Reaction Control systems. All these had different force ratings in the range of 20-21,000 Newtons. The successful flight of ASLV-D3 demonstrates that hundreds of precision components fabricated to close tolerances and assembled in clean environment had performed as predicted.

* Transonic buffeting: Since ASLV had a bulbous heatshield, problems associated with transonic buffeting were only to be anticipated. This problem was overcome by modelling, wind tunnel testing, proper structural design, etc.

* One of the strengths of ISRO, proved over the years, lies in solid propellants. Thus, with confidence, ISRO could use the indigenous HTPB-based propellant in the lower stages of ASLV-D3, obviating the need to import the resin. Also, by adopting the technique of double/triple casting of motors, the differential thrusts between strap-ons could be maintained within the specified limits. The success of ASLV-D3 demonstrated not only the high reliability of the solid propulsion systems but the theoretical tools developed for modelling and prediction.

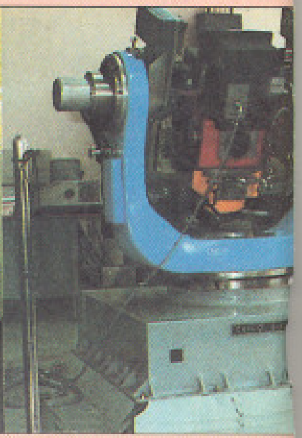
* Unlike SLV-3, the ASLV was integrated vertically at the launch pad. The success of ASLV programme clearly established the efficacy of the complete infrastructure needed for vertical integration including the Mobile Service Structure - a 40 metre tall, weather-proof, tractionable mobile steel building with foldable access platforms, lifts, cranes, clean rooms and other fixtures for integration.

* The network of ground stations at SHAR, Car Nicobar, Thiruvananthapuram and Bangalore, used for tracking the vehicle can undoubtedly be considered as operational and reliable.

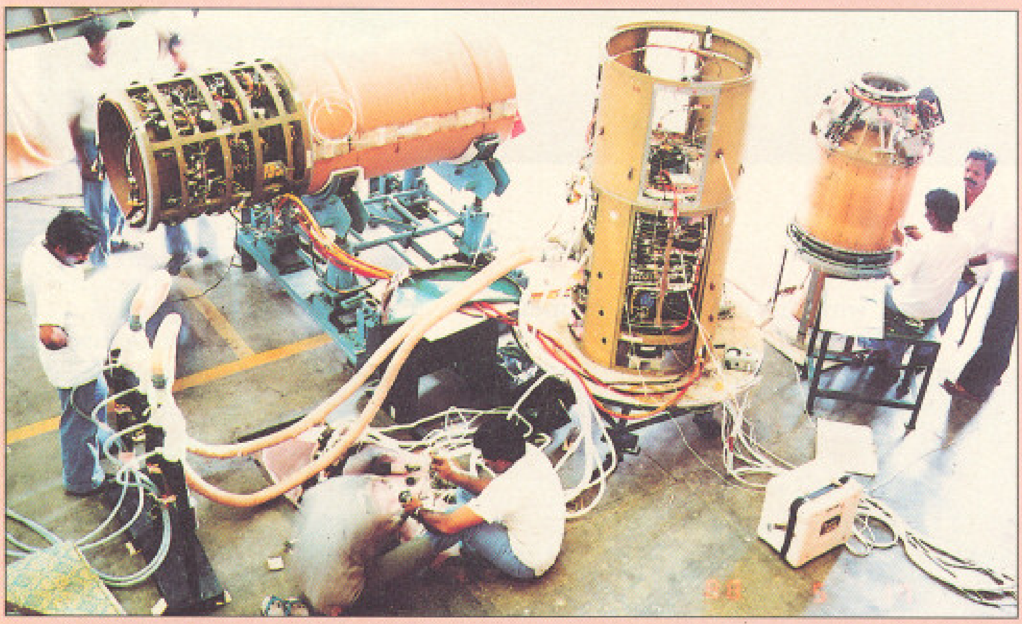
In summary, the success of ASLV-D3 clearly shows that all developmental problems associated with any or all systems, both on board and ground, have been properly analysed and solved. □

INTEGRATION AND C

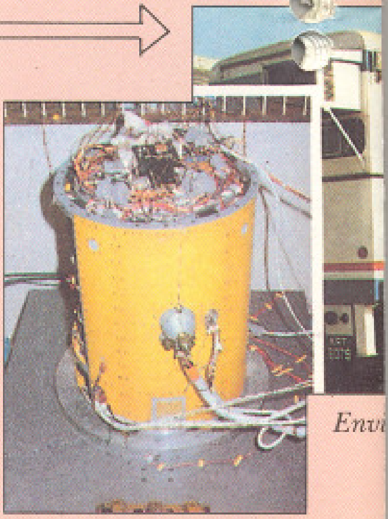
Component testing



Simulation studies



Electrical integration and check out



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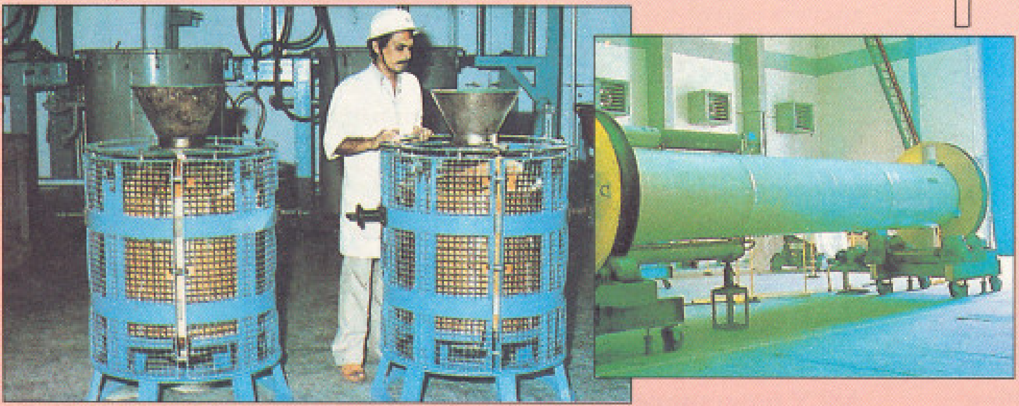
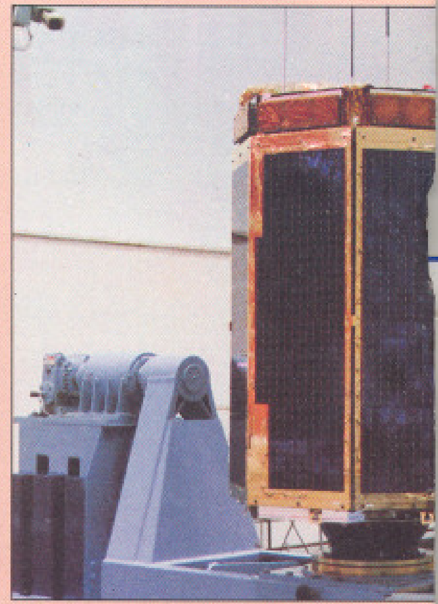


Motor preparation



Satellite integration and testing

HECK OUT SEQUENCE

Check out from Block House

ASLV ready for launch

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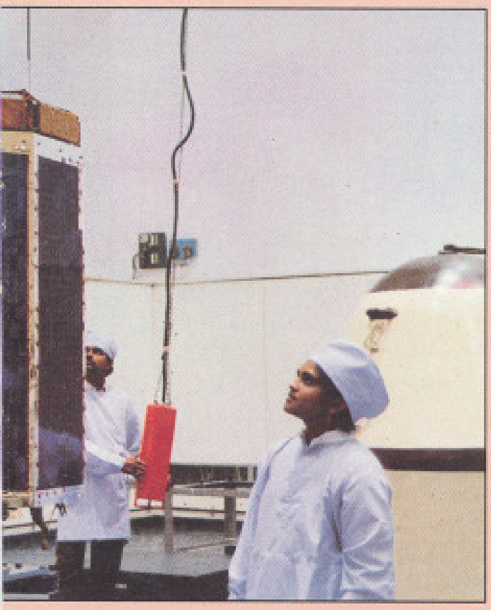
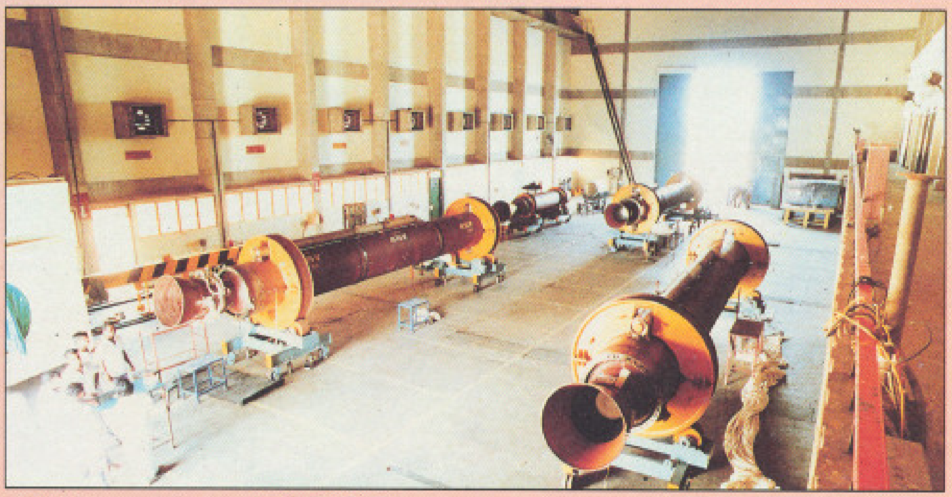
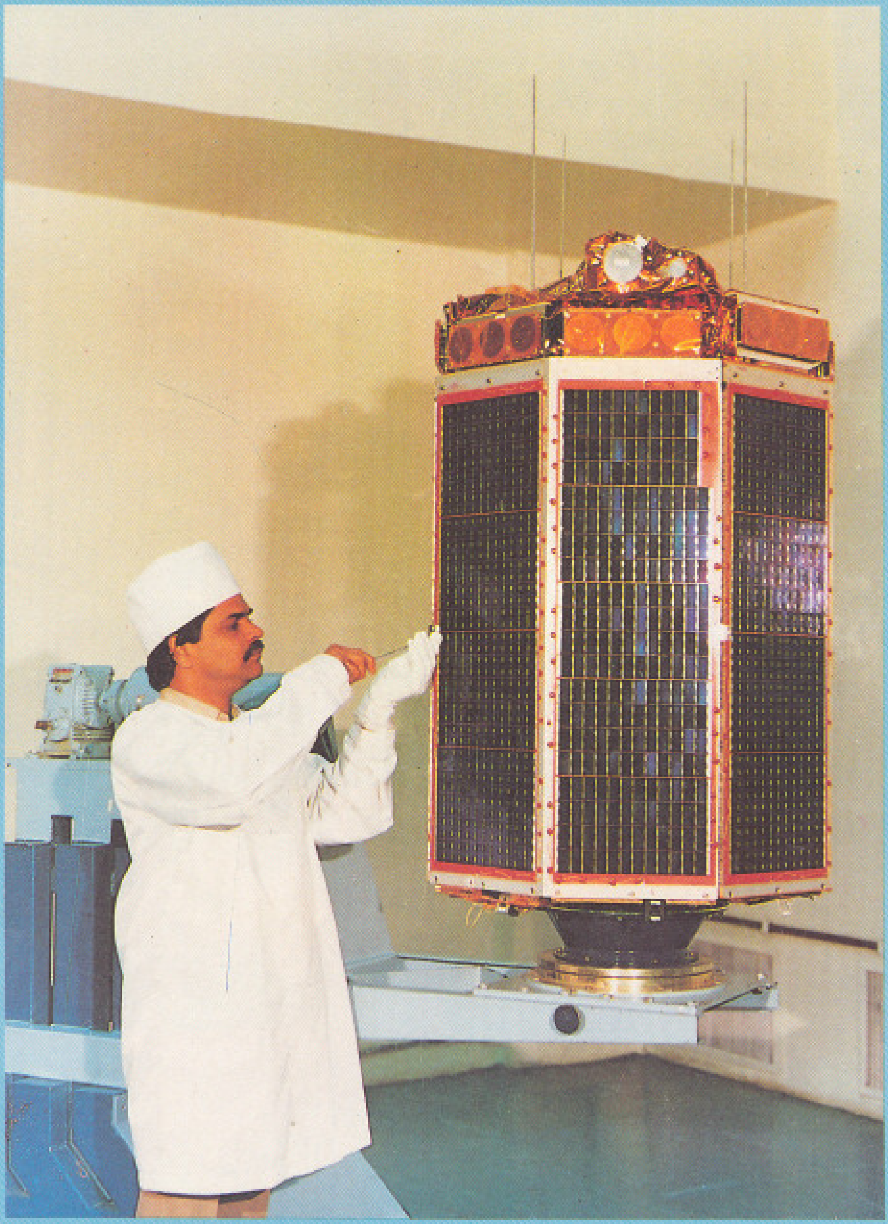




Vehicle integration at VIB (SHAR)

SROSS-C Satellite

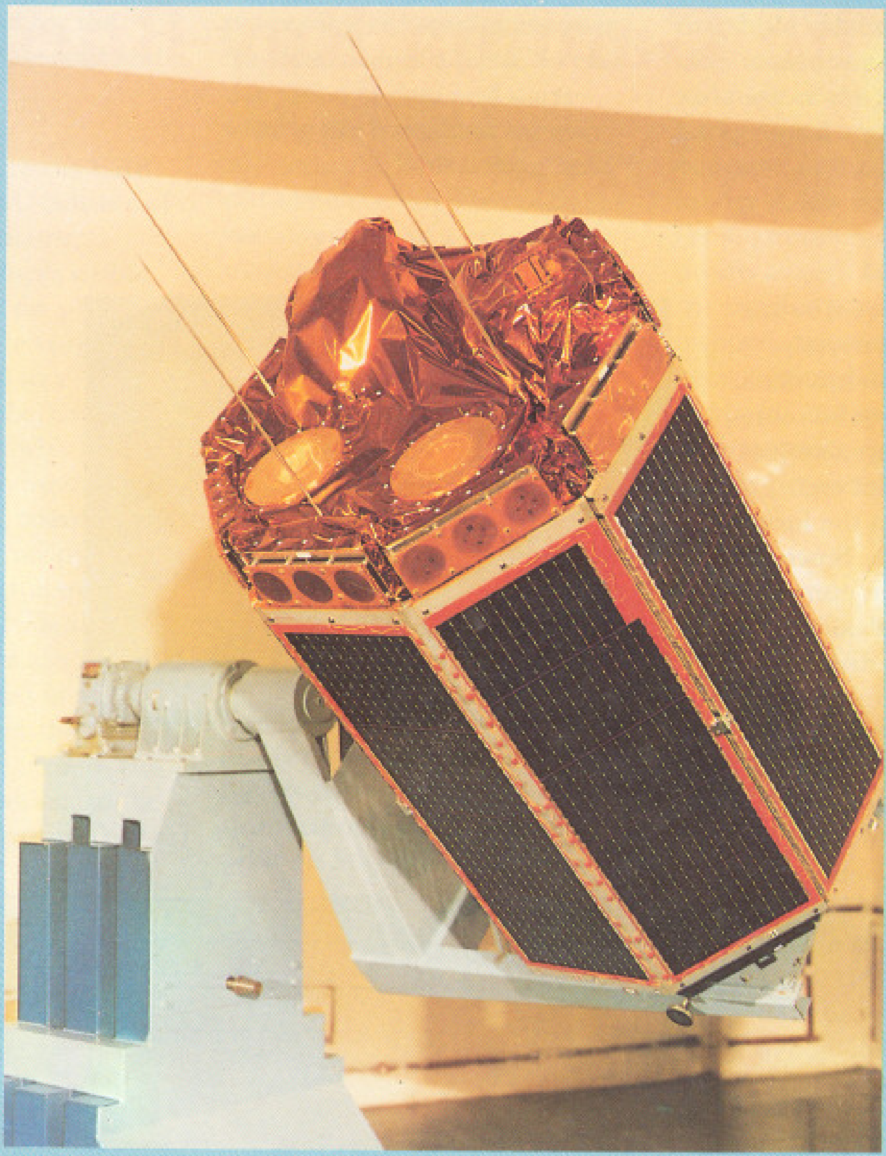


Final preparation of SROSS-C

SROSS-C satellite carried two scientific payloads, an Astronomy payload, namely, the Gamma Ray Burst experiment (GRB) and the other an Aeronomy payload, namely, the Retarding Potential Analyser (RPA). The GRB payload was developed at ISRO Satellite Centre, Bangalore and the RPA was developed at National Physical Laboratory (NPL), New Delhi.

To meet the specific requirements of the payloads, the satellite was configured as a spinner with its spin axis oriented normal to the orbital plane with GRB detectors mounted parallel to the spin axis and RPA detectors mounted perpendicular to the spin axis. The spin axis orientation was controlled to within 2 degree of the orbit normal, while the spin rate was controlled to within 2-5 rpm.

Eight body mounted solar panels on the satellite were used to generate 45 W of electrical power backed up by an 18 Ah battery. The telemetry, tracking and command links were operated in both S-band and VHF-band supporting each other as redundant links. Three magnetometers, one sun sensor, two magnetic torquers and a nutation damper provided all attitude and orbit



SROSS-C on assembly jig

control functions. During the operation of the RPA payload, the satellite was designed to work only on the batteries with the solar panel maintained at zero potential.

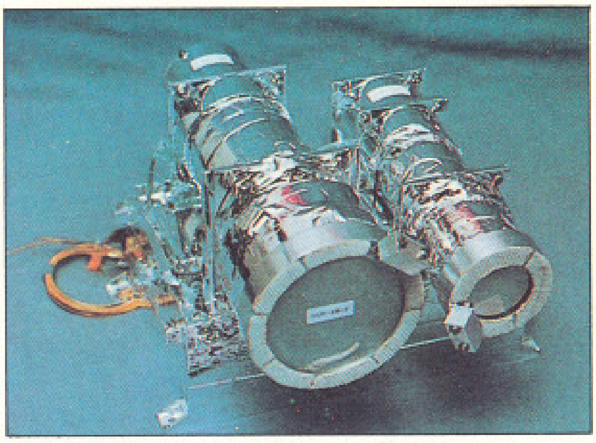
The satellite was injected into the orbit by ASLV with a spin rate of 80 rpm about the longitudinal axis. The fluid-in-tube nutation damper, which dissipates energy, was used to convert the spin to a lateral axis in about 14 hours. The moment of inertia ratio of 0.4 between the longitudinal to lateral spin axes resulted in reducing the spin to 32 rpm. The spin rate was further brought down to 6 rpm by despin torquers in the next 40 hours. The spin axis which was 69 degree away with respect to the desired orbit normal position was corrected by the magnetic torquer in about 15 orbits.

A network of stations located at Bangalore, Sriharikota, Thiruvananthapuram, Lucknow, Mauritius and Bearslake participated in conducting the SROSS mission operations, under overall direction from the ISTRAC Spacecraft Control Centre at Bangalore. The RPA payload was switched 'on' on May 21, 1992, and the GRB on May 27, 1992.

With the satisfactory functioning of the astronomy and ionosphere payloads, and the concurrent measurements with rocket payloads and also the measurements taken by the Mesosphere, Stratosphere and Troposphere (MST) Radar at Gadanki near Tirupati, all the scientific objectives of the SROSS-C satellite have been fully realised. □

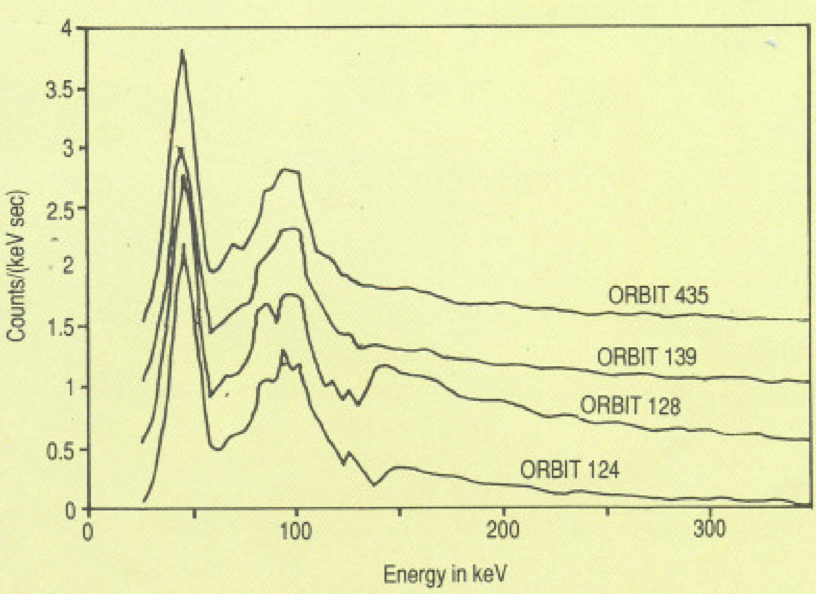
The Gamma Ray Burst Experiment

Gamma Ray Bursts (GRB) are among the most mysterious transient celestial phenomena. These bursts, discovered more than two decades ago, last just for a few seconds and emit enormous energy in the form of gamma ray photons. Since the bursts have not been correlated with visible stars, galaxies or other objects, their distances have remained completely unknown. There are conflicting theories regarding the origin of the burst– for example, collision of a comet or an asteroid with galactic neutron stars, neutron star crust quake, thermonuclear run away reaction of the neutron star or even exotic possibilities like extra galactic origin. No one for sure knows the exact origin of these high energy photons. It is, therefore, very important to observe these events and study their temporal and spectral characteristics from a variety of platforms, including satellite.



Gamma Ray Burst payload

The Gamma Ray Burst payload on the SROSS-C satellite, was intended to: (i) monitor the gamma ray bursts in the energy range of 20 keV to 3 MeV; (ii) determine their intensity variation with high time resolution to search for periodicities in the emission which in turn will help deduce the nature of the sources; (iii) determine the temporal evolution of burst energy spectra and; (iv) map the radiation background in low

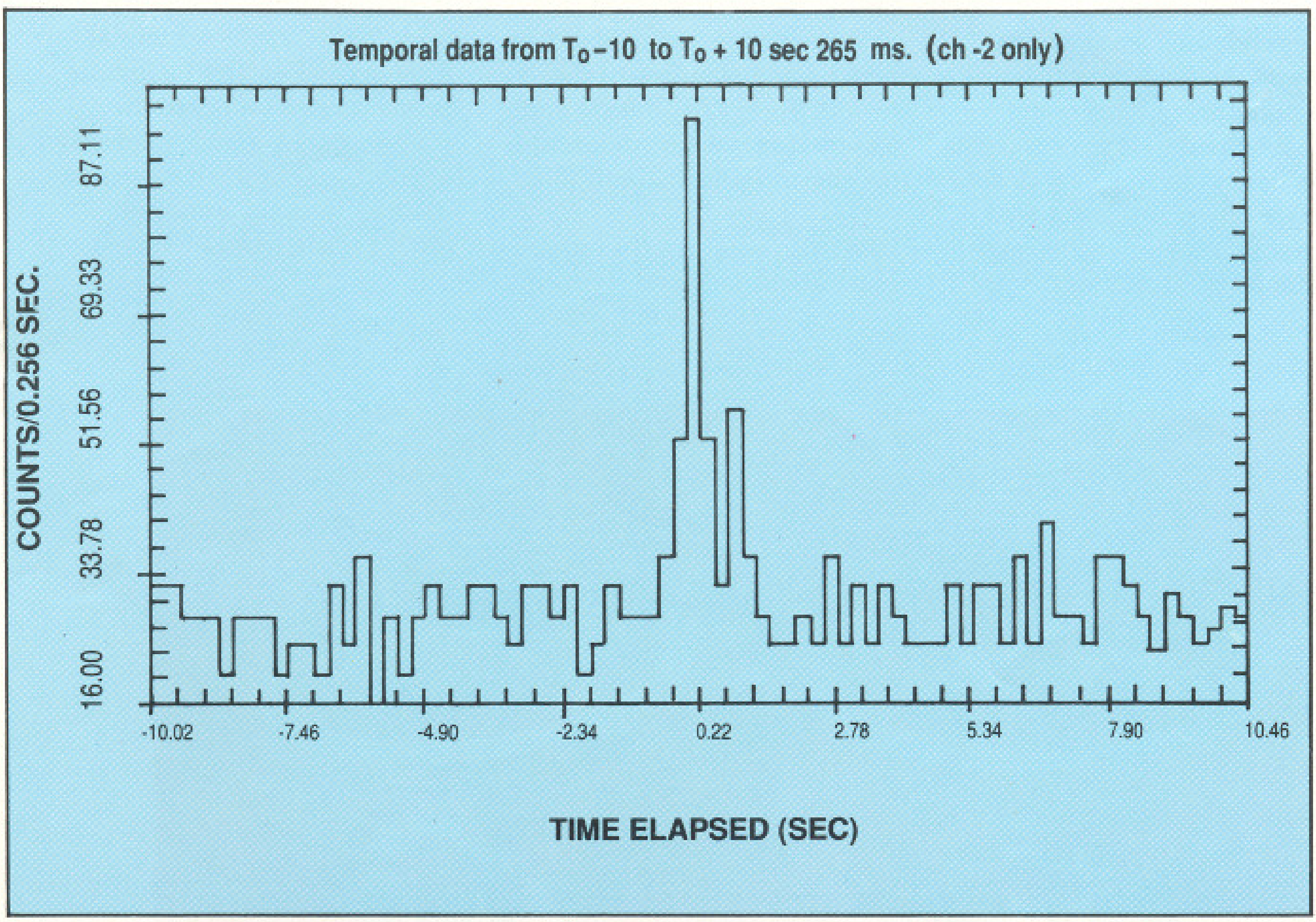


BACKGROUND RADIATION AT THE EQUATOR

earth orbits, helpful for the design of future spacecraft and experiments.

The detector used in the GRB payload on SROSS-C consists of an inorganic scintillator, CsI(Na), that produces visible light when gamma ray photons interact with it. The scintillator is optically coupled to a photomultiplier tube, the electrical output of which is amplified and processed by a microprocessor on board. The number of gamma ray photons incident on the crystal over different time intervals and their energy spectra are measured and stored in an 8 k byte memory. When the photon arrival rate exceeds the preset threshold (which can be commanded from ground), the processing electronics assumes the detection of a burst, freezes the preburst data and starts writing the burst data for over 200 seconds. This is then read out when the satellite enters the visibility zone of a ground station. The best time resolution obtained around the peak of a burst is 2.0 milli second and the best spectral resolution is 4 keV/channel in the energy range 20-256 keV. In the background mode of operation of the experiment covering one full orbit, 52 spectra, each of about 100 seconds duration can be measured and stored on board.

After allowing a week for degassing of materials used in the spacecraft, the payload was switched on during the 119th orbit on May 27,1992. The threshold values were fixed after measuring the latitude variation of the radiation background and the payload operated in the burst-search mode. A few interesting events (and a number of false triggers, mostly at high latitudes when the satellite passes through the trapped radiation zones) have been detected. Analysis of the temporal and spectral data of all interesting events detected is now in progress. □



The temporal profile of a Gamma Ray burst detected in orbit 377, in the energy range 100 keV to MeV. This has got the characteristics of a typical gamma ray burst. The total counts per 265 ms is plotted from 10 sec prior to 10 sec after the burst detection.

On to PSLV -heatshield for PSLV