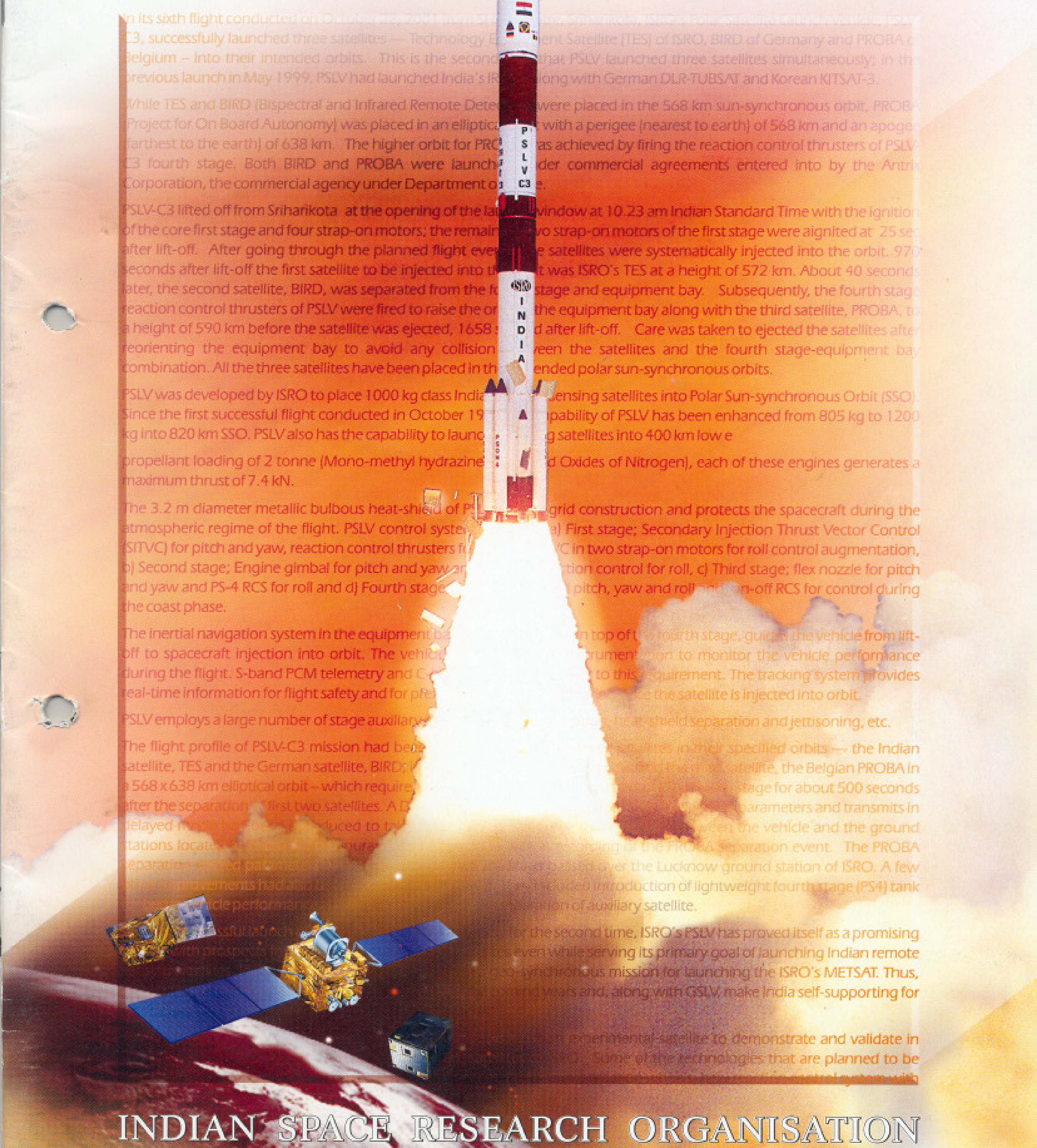
October -December 2001

SPACE india



INDIAN SPACE RESEARCH ORGANISATION

INSAT-3C Launch In January 2002

The Indian National Satellite, INSAT-3C, designed and built by ISRO, was airlifted from Bangalore on December 02, 2001 to Kourou, French Guyana for its launch now scheduled for mid January 2002.

INSAT-3C carries 24 C-band transponders, six extended C-band transponders, two S-band broadcast satellite service transponders and mobile satellite service transponders. Once commissioned, the satellite will further augment the present INSAT capacity. INSAT-3C will be positioned at 74-degree east longitude.

INSAT-3C, which was ready in August, was to be launched by an Ariane-5 vehicle of the Arianespace. However due to the failure of one of its Ariane-5 and consequent delay in the follow-on launches, INSAT-3C launch was put off. Arianespace subsequently offered an exclusive Ariane-4 launch vehicle for launching INSAT-3C.

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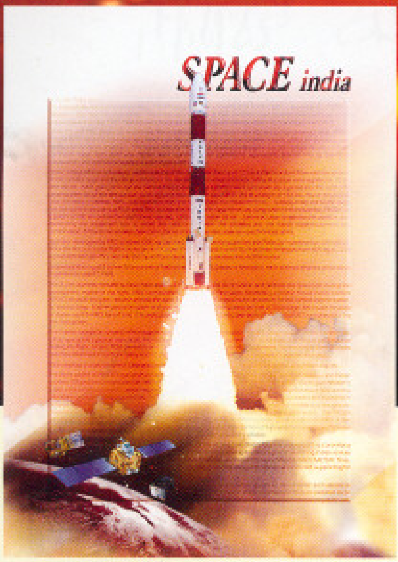

Cover Page :
PSLV-C3 lift-off

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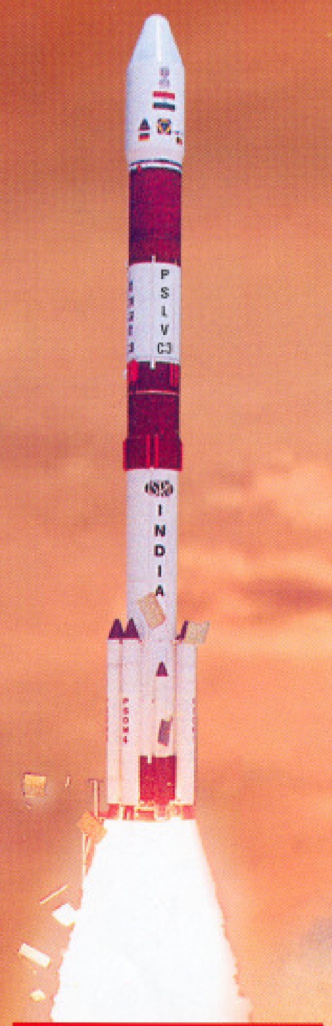
COVER STORY

PSLV Places Three Satellites *in* Orbit



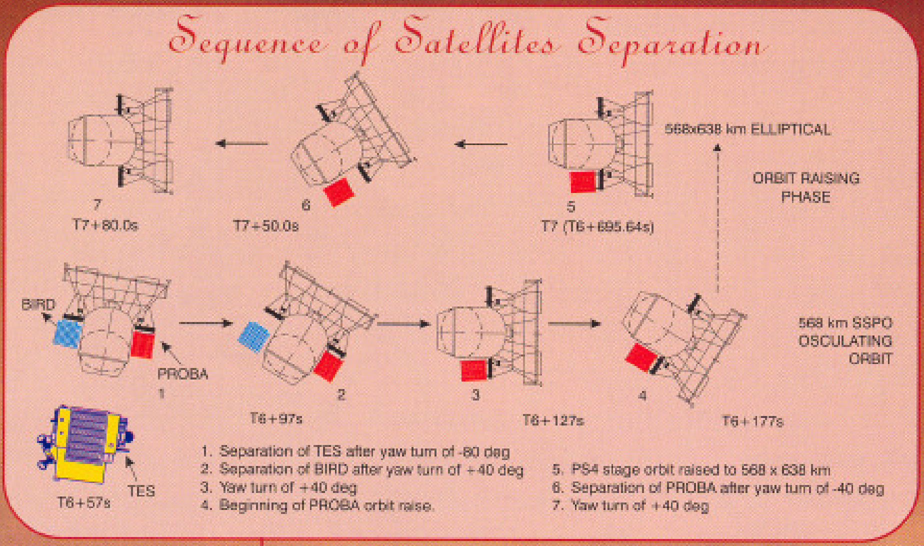
In its sixth flight conducted on October 22, 2001 from SHAR Centre, Sriharikota, ISRO's Polar Satellite Launch Vehicle, PSLV-C3, successfully launched three satellites — Technology Experiment Satellite (TES) of ISRO, BIRD of Germany and PROBA of Belgium – into their intended orbits. This is the second time that PSLV launched three satellites simultaneously; in the previous launch in May 1999, PSLV had launched India's IRS-P4 along with German DLR-TUBSAT and Korean KITSAT-3.

While TES and BIRD (Bispectral and Infrared Remote Detection) were placed in the 568 km sun-synchronous orbit, PROBA (Project for On Board Autonomy) was placed in an elliptical orbit with a perigee (nearest to earth) of 568 km and an apogee (farthest to the earth) of 638 km. The higher orbit for PROBA was achieved by firing the reaction control thrusters of PSLV-C3 fourth stage. Both BIRD and PROBA were launched under commercial agreements entered into by the Antrix Corporation, the commercial agency under Department of Space.

All the three satellites have been placed in their intended polar sun-synchronous orbit

PSLV-C3 lifted off from Sriharikota at the opening of the launch window at 10.23 am Indian Standard Time. The lift-off was initiated with the ignition of the core first stage and four strap-on motors; the remaining two strap-on motors of the first stage were ignited at 25 sec after lift-off. 970 seconds after lift-off the first satellite, ISRO's TES, was ejected at a height of 572 km. About 40 seconds later, the second satellite, BIRD, was separated from the fourth stage and equipment bay. Subsequently, the fourth stage reaction control thrusters of PSLV were fired to raise the orbit of the equipment bay along with the third satellite, PROBA, to a height of 590 km before the satellite was ejected, 1658 second after lift-off. Care was taken to eject the satellites after reorienting the equipment bay to avoid any collision between the satellites and the fourth stage-equipment bay combination. All the three satellites were placed in their intended polar sun-synchronous orbits.

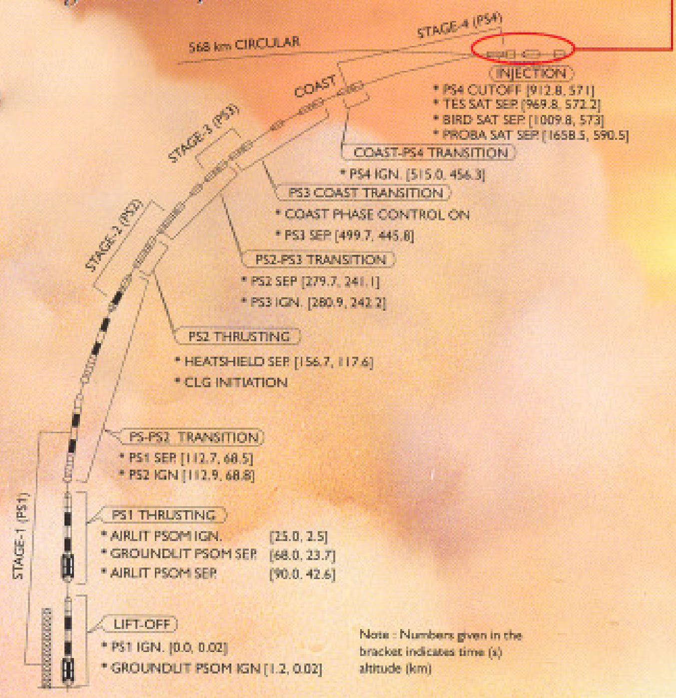
PSLV was developed by ISRO to place 1000 kg class Indian remote sensing satellites into Polar Sun-synchronous Orbit (SSO). Since the first successful flight conducted in October 1994, the capability of PSLV has been enhanced from 805 kg to 1200 kg into 820 km SSO. PSLV also has the capability to launch 3,500-kg satellites into 400 km low earth orbit and 1000kg satellites into Geo-synchronous Transfer Orbit.



In its present configuration, the 44.4 metre tall, 294 tonne PSLV has four stages using solid and liquid propulsion systems alternately. The first stage is one of the largest solid propellant boosters in the world and carries 138 tonne of Hydroxyl Terminated Poly Butadiene (HTPB) propellant. It has a diameter of 2.8 m and its motor case is made of maraging steel. The booster develops a maximum thrust of about 4,430 kN. Six strap-on motors, four of which are ignited on the ground, augment the first stage thrust. Each of these solid propellant strap-on motors, carries nine tonne HTPB propellant and produces 667 kN thrust.

The second stage employs indigenously manufactured Vikas engine and carries 40 tonne liquid propellant — Unsymmetrical Di-Methyl Hydrazine (UDMH) as fuel and Nitrogen tetroxide (N_2O_4) as oxidiser. It generates a maximum thrust of about 724 kN.

Flight Profile



The third stage uses 7 tonne of HTPB-based solid propellant and produces a maximum thrust of 324 kN. Its motor case is made of polyaramide (Kevlar) fibre. 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 and Mixed Oxides of Nitrogen), each of these engines generates a maximum thrust of 7.4 kN.

The 3.2 m diameter metallic bulbous heat-shield of PSLV, is of isogrid construction and 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

PSLV-C3 Salient Features

• Overall length	:	44.4 m
• Lift-off weight	:	294 t
• No. of stages	:	4
• Payload	:	TES , BIRD, PROBA
• Orbit (SSO)	:	570 km PSLV Propulsive Stages at a Glance

for pitch, yaw and roll and, on-off RCS for control during the coast phase.

The inertial navigation system in the equipment bay, which is located on top of the fourth stage, guides the vehicle from lift-off to spacecraft injection into orbit. The vehicle is provided with instrumentation to monitor the vehicle performance during the flight. S-band PCM telemetry and C-band transponders cater to this requirement. The tracking system provides real-time information for flight safety and for preliminary orbit determination once the satellite is injected into orbit.

Stage	Nomen-clature	Propellant	Propellant mass(t)	Thrust (kN)	Burn time(s)	Stage Dimension Dia(m)	L(m)
1	PS1 + PSOM 6 Nos.	SOLID HTPB BASED SOLID HTPB BASED	138 + 6x9	4430 6x677	108 45	2.8 1.0	20 11.3
2.	PS2	LIQUID UDMH + N204	40	724	162	2.8	12.5
3.	PS3	SOLID HTPB BASED	7	324	76	2.0	3.6
4.	PS4	LIQUID MMH + MON	2	2x7.4	421	2.8	2.6

PSLV employs a large number of stage auxiliary systems for stage separation, heat-shield separation and jettisoning, etc.

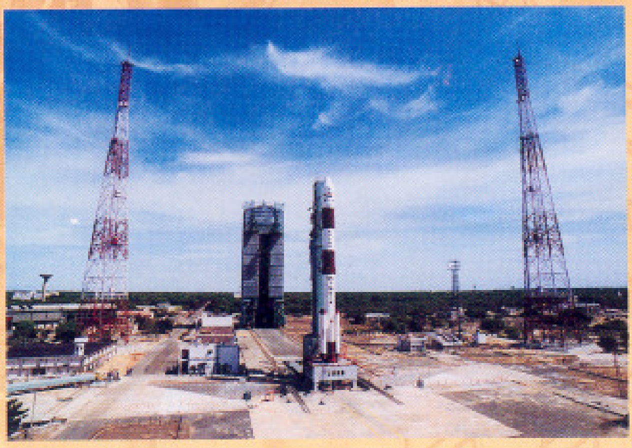
The flight profile of PSLV-C3 mission had been modified to place the three satellites in their specified orbits — the Indian satellite, TES and the German satellite, BIRD, in a 568 km sun-synchronous orbit and the third satellite, the Belgian PROBA in a 568 x 638 km elliptical orbit – which require firing the reaction control thrusters of PSLV fourth stage for about 500 seconds after the separation of first two satellites. A Data Storage Unit (DSU), which stores the telemetry parameters and transmits in delayed mode had been introduced to take care of any break in the radio visibility between the vehicle and the ground stations located at Thiruvananthapuram and Mauritius as well as recording of the PROBA separation event.

PSLV Flight History

Vehicle	Date	Result
1. PSLV-D1	20-09-1993	Unsuccessful due to guidance and control processor software error
2. PSLV-D2	15-10-1994	Successful
3. PSLV-D3	21-03-1996	Successful
4. PSLV-C1	29-09-1997	Successful
5. PSLV-C2	26-03-1999	Successful
6. PSLV-C3	22-10-2001	Successful

The PROBA separation related parameters were transmitted when the stage passed over the Lucknow ground station of ISRO. A few other improvements had also been carried out in PSLV-C3. They included introduction of lightweight fourth stage (PS4) tank for better vehicle performance and ball-lock system for the separation of auxiliary satellite.

With the successful launch of three satellites simultaneously for the second time, ISRO's PSLV has proved itself as a promising vehicle with prospects for commercial launching of satellites even while serving its primary goal of launching Indian remote sensing satellites. PSLV is also proposed to be used for a geo-synchronous mission for launching the ISRO's METSAT. Thus, PSLV is poised to become a versatile launch vehicle in the coming years and, along with GSLV, make India self-supporting for its launch services in the near future.



Launch Complex

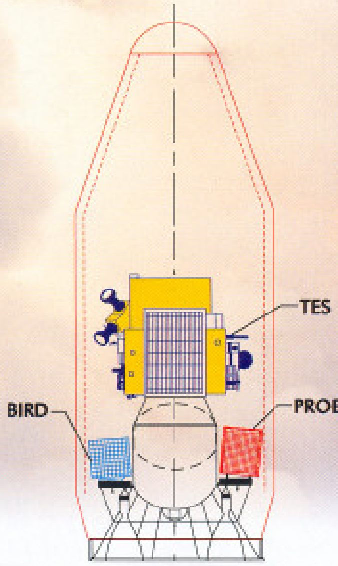
PSLV-C3 Passengers

> *This is the second time that three satellites have been launched simultaneously by PSLV*

The Technology Experiment Satellite, TES, weighing 1108 kg, is an experimental satellite to demonstrate and validate in orbit, technologies that could be used in the future satellites of ISRO. Some of the technologies that are planned to be demonstrated in TES are attitude and orbit control system, high-torque reaction wheels, new reaction control system with optimised thrusters and a single propellant tank, light-weight spacecraft structure, solid state recorder, X-band phased array antenna, improved satellite positioning system, miniaturised TTC and power systems and, two-mirror-on-axis camera optics. TES also carries a panchromatic camera for remote sensing experiments.

Soon after its injection into orbit, the solar panels on board TES were deployed automatically to generate necessary electrical power for the satellite. Further in a series of operations conducted from the ISRO Telemetry, Tracking and Command (ISTRAC) stations at Bearslake in Russia and Lucknow in India, the satellite was put in three-axes stabilised mode using the reaction wheels on board the satellite. The high-resolution camera on board TES has shown a very good performance.

PROBA (Project for On Board Autonomy) is a small satellite of Verhaert, Belgium weighing 94 kg. The payloads in the satellite include high-resolution camera with 115 mm diameter aperture and wide angle camera having aperture of 60 mm. BIRD (Bispectral and Infrared Remote Detection) is a small satellite of the German Space agency, DLR, weighing 92 kg. It is intended for testing small satellite technologies and a new generation of infrared sensors for the detection of hot spots like forest fires and volcanoes from space.



Prime Minister's Message

I am very happy that India has today successfully launched the Polar Satellite Launch Vehicle from Sriharikota, putting in orbit our Technology Experiment Satellite, along with satellites of Belgium and Germany. It is yet another step forward by us in offering reliable multiple orbit launches, not only for India but also for the entire global space community.

PSLV, along with our Geo-synchronous Satellite Launch Vehicle, GSLV, which had its first successful flight test in April last, has made our space programme self-reliant, not only in building our satellites like INSAT and IRS, but also to launch them using our own launch vehicles.

The TES is a technology breakthrough in optical imaging systems, which our Scientists have achieved entirely indigenously.

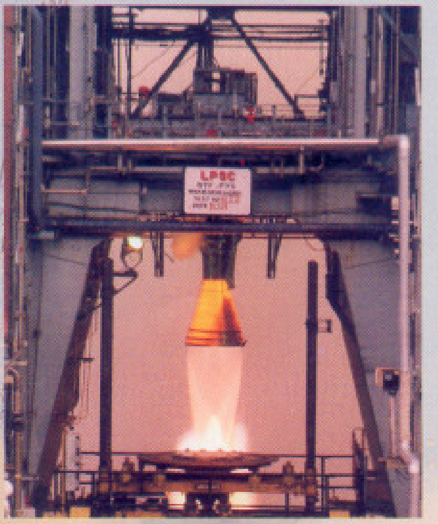
I congratulate the team of Scientists and Engineers and all others involved in this mission. They have indeed done the country proud. I wish them success in all their future endeavors.

New Delhi
October 22, 2001

A B Vajpayee

Up-rated Liquid Propellant Engine Tested Successfully

ISRO successfully tested an up-rated version of the liquid propellant Vikas engine at its Liquid Propulsion Test Facilities at Mahendragiri in



TamilNadu on November 30, 2001. The Vikas engines are employed in the second stage of India's Polar Satellite Launch Vehicle (PSLV) as well as the second and the four strap-on stages of Geo-synchronous Satellite Launch Vehicle (GSLV).

The up-rated version of the Vikas engine developed a chamber pressure of 58.5 bar during the test against 52.5 bar in the current version of the engine. The new engine uses UH25 (a mixture of Unsymmetrical Di-methyl Hydrazine and hydrazine hydrate) as fuel and nitrogen tetroxide as oxidiser. In addition to the verification of performance of the engine for full duration, the test has also validated the Silica-phenolic throat for the extended duration of burning time. Before the test conducted on November 30, 2001, a number of short-duration tests had been conducted to check the inter-play of various parameters to ensure a stable combustion.

The new Vikas engine is planned to be introduced in the second developmental test flight of GSLV, which is scheduled during 2002. The new engine has the potential to increase the payload capability of GSLV by about 150 kg in the Geo-synchronous Transfer Orbit (GTO).

A RADAR For Weather Watch

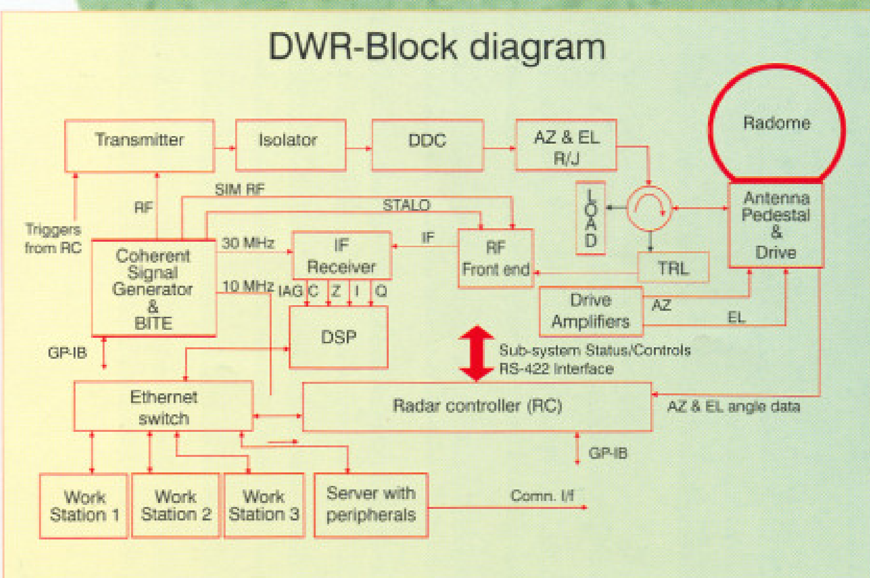
ISRO has developed a Doppler Weather Radar (DWR) system for India Meteorological Department (IMD) to help in cyclone detection and characterization of severe weather. The first of the DWR system is expected to be operational at ISRO's SHAR Centre, Sriharikota shortly..

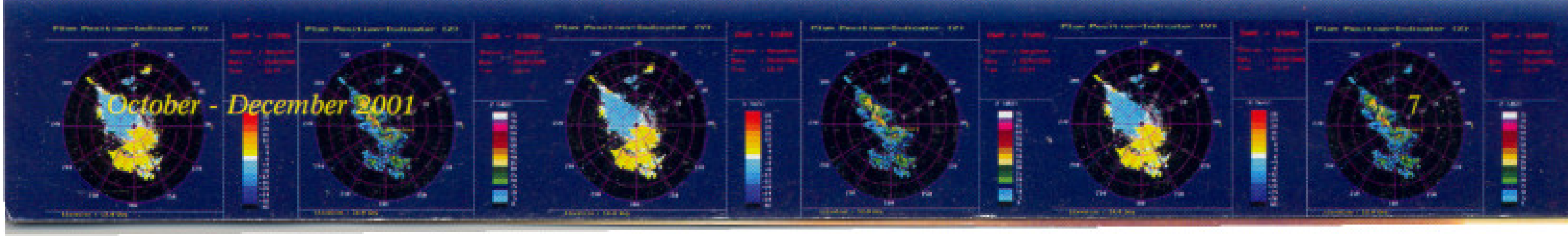
Pulse Doppler techniques are being increasingly employed in weather radars to characterize severe weather systems more accurately. In particular, digital signal analysis and graphic utilities of the system help in real time display of the development of thunderstorms, cyclones and tornadoes, providing quantitative measures of severe weather, intensity, track and detailed information on the wind fields of the associated hydrometeors. This new class of radars, known as Doppler Weather Radar System (DWR), provides precise warnings, enhancing the lead-time available for saving lives and property in the event of natural disasters associated with severe weather.

The design and development of DWR was taken up as an inter-agency programme with India Meteorological Department (IMD), which provides the national weather service including timely alerts on cyclones and thunder storms to serve the weatherman's needs in the new millennium.

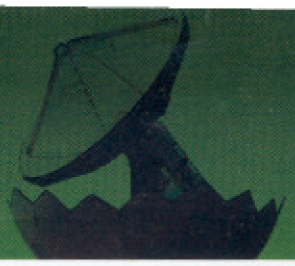
DWR operates in S-band (10 cm wavelength) and is normally configured as a fixed station. Provision is made for networking DWRs located at different places through either a land-based or a satellite-based digital data network. DWR consists of a high power coherent transmitter and a pencil beam antenna with one-degree beam width and very low side lobes. The antenna can be steered both in azimuth and elevation and the scanning programmed through a radar controller. The antenna assembly is protected from severe wind conditions by a low loss sandwich radome. A high dynamic range receiver with the low noise front-end enables detection of weak echoes including clear air turbulence. A digital signal processor extracts the three essential base parameters —

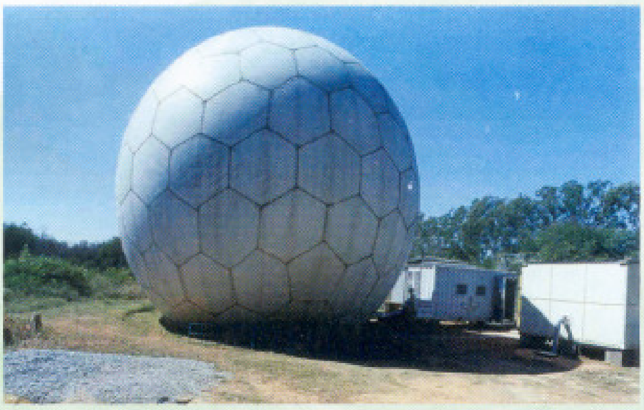
Pulse Doppler techniques are being increasingly employed in weather radars to characterize severe weather systems more accurately





A RADAR For Weather Watch





DWR installation showing the radome and other equipment located in the containers

Reflectivity, Mean velocity and Spectral band width of hydrometeors — from the log/linear channels of the receiver. Work stations with high-resolution graphics compute and display meteorological data derived from the three base products. The entire DWR is operated by a single person using a PC-based controller. The system can be operated in an automatic mode with programmable volume scanning at chosen azimuth rate and specified number of elevation steps.

ISRO had started development of Radars in 1970. The development of C-band tracking radars for ISRO's SHAR Centre at Sriharikota was the first major project. Since then a variety of Radars like C-Band and S-Band Radars, Precision Coherent Monopulse C-band (PCMC) Radars and the Mesosphere-Stratosphere-Troposphere (MST) Radars have been developed successfully. In all these developments, ISRO has associated several institutions like the Bharat Electronics at Bangalore, Electronics and Radar Development Establishment at Bangalore and Society for Microwave Enginnering Research (SAMEER), resulting in a core expertise to be developed. This expertise has been effectively used in developing the DWR system that can help IMD in improving the weather forecasting especially the severe weather conditions helping in saving lives and properties.

Overall Technical Specifications

Operating frequency	: 2.7-2.9 GHz
Radome	: Foam sandwich rigid, spherical
Diameter	: 12.8 m
RF loss	: 0.2 dB one way (dry radome)
Structure	: Self supporting
Type	: Curved sandwich
Wind speeds	: 250 kmph average, 300 kmph gusting
Antenna	: Prime focus parabolic dish
Diameter	: 9 m nominal
F/D ratio	: 0.35
Beam width	: 0.95 deg @ 2.8 GHz
Feed	: Scalar with OMT
Polarization	: Linear Horizontal & Linear Vertical
Steerability	: 360 deg in AZ, -2 to +90 deg in E1
Rotation rate	: 3 rpm
Pointing Accuracy	: +/- 0.1 deg
Transmitter	: Coherent – Klystron based
Peak power	: 1.0 MW (typical)
Pulse power	: 1 sec & 2 sec (selectable)
PRF	: 250 – 1200 Hz (selectable)
Modulator	: Tetrode based hard tube modulator
Other wave forms	: Possible within duty ratio limits
Receiver	: Coherent
Dynamic range	: 80 dB Linear channel with IAGC 95 dB for Log Channel
Noise figure	: 3 dB (typ.)
IF	: 30 MHz
IF bandwidth	: 1.4 MHz, 0.7 MHz (selectable)
Signal Processor	: Floating point DSP (TMS 320C44 based)
ADC	: 14 bit
Sampling rate	: Selectable upto 3 MS/Sec
No. of range bins	: Selectable upto 2048
Range resolution	: Commensurate with ADC sampling rate 300 m (default)
Clutter suppression	: 30 dB & 50 dB using IIR filter
DSP Algorithms	: Reflectivity : averaging Velocity & Spectral width : Pulse pair, FFT (optional)

Stop Press

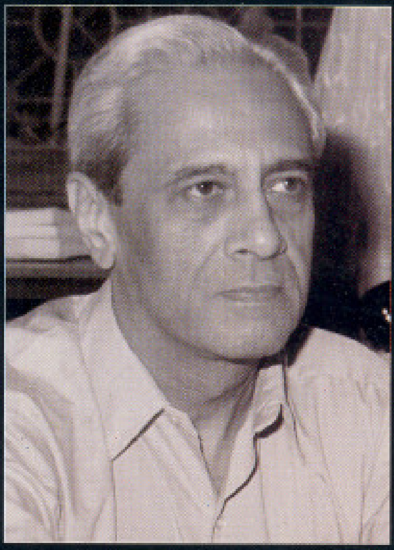
Prof Satish Dhawan Passes Away

"…. the award goes fittingly to one of our foremost scientists, teachers, and national builders, Prof Satish Dhawan, who has made multi-dimensional contributions to scientific education, research, policy formulation and implementation and is deeply concerned with the solution of national problems through the use of science…"

…citation of 1999 Indira Gandhi Award for National Integration.

Prof Satish Dhawan, former Chairman of ISRO, passed away on January 3, 2002 at Bangalore. A multi-faceted personality, Prof Dhawan, was truly one of the most distinguished Indians of our times – a brilliant aeronautical engineer, an outstanding space scientist, a philosopher, a humanist, and above all, a great visionary. His great human qualities, combining intense personal charm with a deep commitment to social values and an extraordinary objectivity in management, led several generations of students, colleagues and administrators to efforts that would not have been undertaken otherwise.

Prof Dhawan was born on September 25, 1920 in Srinagar. He hailed from a distinguished family — his father was a high-ranking civil servant of the undivided India and retired as the resettlement Commissioner of Government of India at the time of partition. One of his uncles, B D Dhawan, was Governor of Punjab.



Prof Dhawan graduated from the University of Punjab with an unusual combination of degrees — BA in Mathematics and Physics, MA in English Literature and a BE in Mechanical Engineering. In 1947, he obtained an MS in Aeronautical Engineering from the University of Minnesota, and moved to the California Institute of Technology, where he was awarded the Aeronautical Engineer's Degree in 1949 and a Ph.D in Aeronautics and Mathematics in 1951 with Prof Hans W Liepmann as adviser.

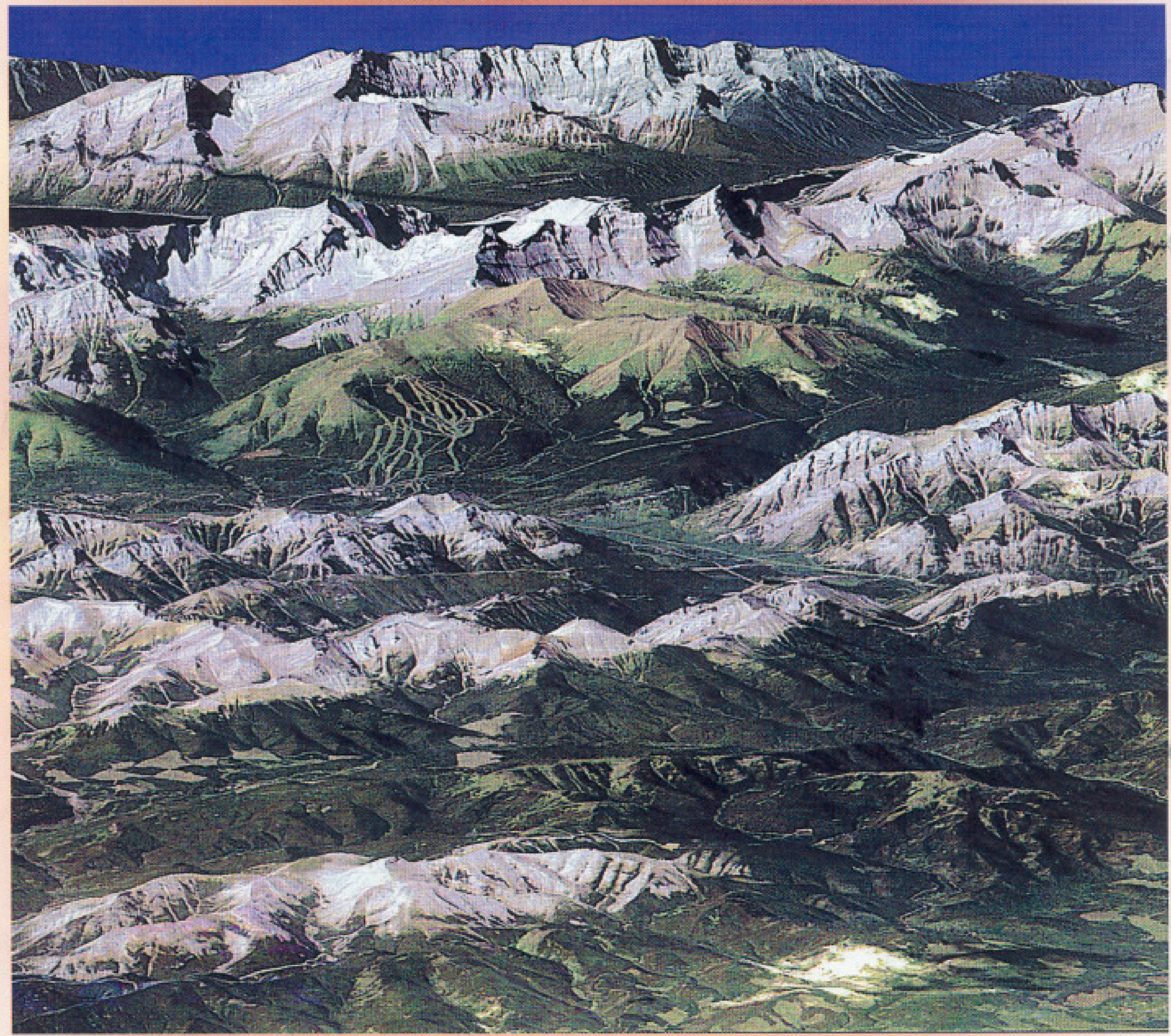
Prof Dhawan joined the Indian Institute of Science, Bangalore in 1951 of which he became Director in 1962. Two outstanding features of his tenure as the Director of Institute reveal his philosophy in research – first, they were carried out at low cost with indigenous development or adaptation of available materials, skills and instrumentation and second, the basic research areas investigated in his laboratories were all inspired in some way by the problems faced by the newly-born aircraft industry of the country.

Prof Dhawan took over as Chairman of Space Commission and Chairman, ISRO, and Secretary to the Government of India in the Department of Space in 1972. In the following decade, Prof Dhawan directed the Indian space programme through a period of extraordinary growth and spectacular achievements. The Indian space programme reached a state of high maturity. In doing so, he provided a model for the country on how to define, formulate and organize high technology projects and deliver sophisticated products within stipulated time frames. Major programmes on satellite and launch vehicles were carefully defined and systematically executed and pioneering experiments were carried out in remote sensing and satellite communications under Prof Dhawan's leadership. Even after he retired as Chairman, ISRO and Secretary, Department of Space, in 1984, he continued to give advice on the space programme, which was always marked by scrupulous objectivity and a deep concern for the society's problems.

Prof Dhawan's stewardship of ISRO was distinguished by his keen sensitivity to the true needs of a developing nation, a confident appreciation of the ability of ISRO's scientists and engineers, and the involvement of Indian industry, both public and private. But what was striking about Prof Dhawan was his deep commitment to human values and the use of science and technology for development. The space community in India owes deep gratitude to Prof Dhawan for imbibing in the community an abiding sense of technological excellence, human values, and social commitment.

While Prof Dhawan was bestowed many awards for his contribution to science and technology by various bodies within India and abroad, the citation presented to Prof Satish Dhawan when he was awarded the 1999 Indira Gandhi Award for National Integration brings out the essence of the man:

"…. the award goes fittingly to one of our foremost scientists, teachers, and national builders, Prof Satish Dhawan, who has made multi-dimensional contributions to scientific education, research, policy formulation and implementation and is deeply concerned with the solution of national problems through the use of science…"



A stereoscopic colour imagery of Kananaskis, Alberta, Canada generated using data received from India's IRS-1C and LANDSAT of USA

Courtesy : Space Imaging, USA