3/1987

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

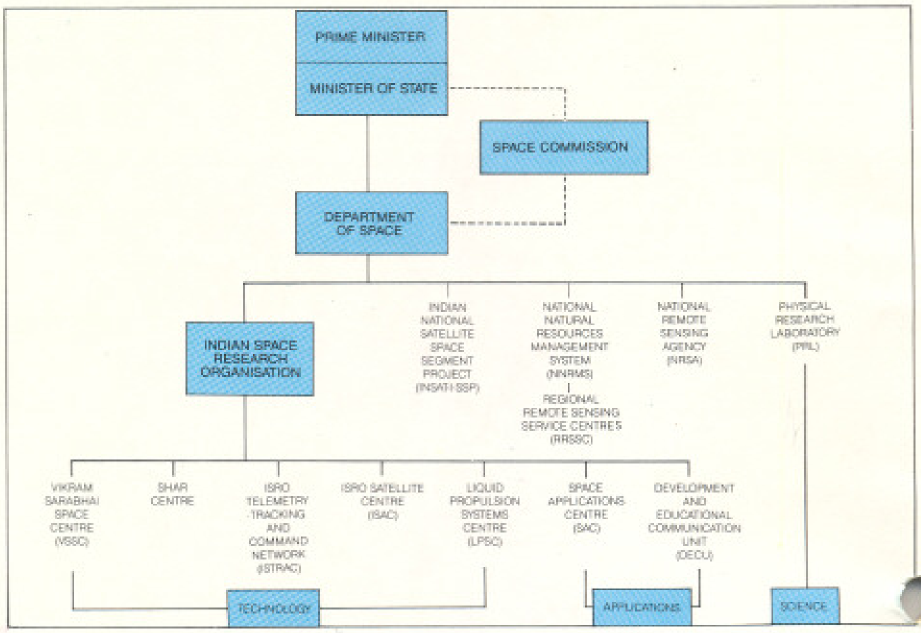
THE INDIAN SPACE PROGRAMME

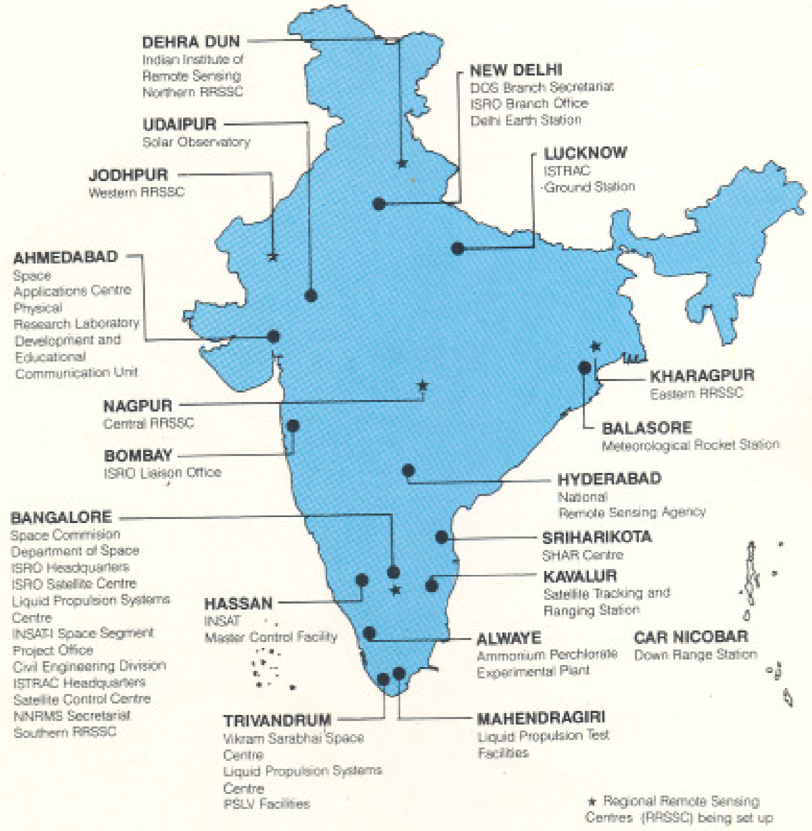
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science 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
A model of IRS Satellite being readied for thermal vacuum tests.

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Contents

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IRS

Indian Remote Sensing Satellite

Accurate and timely information on various natural resources is essential for the planned development of any country. Space-based earth observation systems offer unique possibilities for synoptic and systematic acquisition of such information with short turn-around times. The Indian Space Research Organisation (ISRO) conducted the Bhaskara I and the Bhaskara II experimental satellite programmes during 1979-82 which provided valuable experience on space-based remote sensing. This includes the definition of sensor systems, design and operation of a space platform, data reception, processing, interpretation and utilisation. IRS represents the next logical step in consolidating this experience towards an operational satellite-based remote sensing system.

IRS-1A is the first of a series of satellites to form the space-segment of the country's National Natural Resources Management System (NNRMS). Rectangular parallelopiped in shape, the satellite weighs 960 kg and will be placed into a polar sun-synchronous orbit of 904 km altitude by a Soviet rocket carrier sometime later this year. The payload consists of three state-of-the-art cameras using Charge Coupled Devices (CCD) as detectors. The design of the cameras is based on the concept of 'push broom' scanning, using linear imaging self-scanned sensors (LISS). In this mode of operation, each line of the image is electronically scanned by a linear array of detectors located in the focal plane of the system and successive lines of the image are produced as a result of the satellites' movement. This

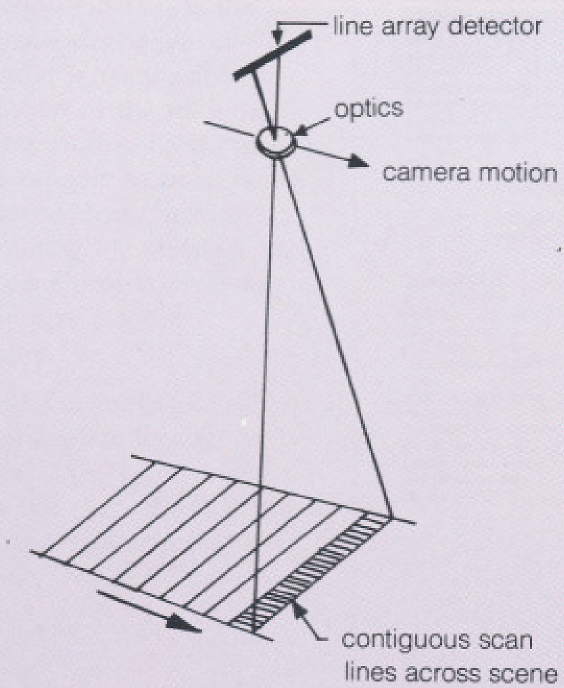
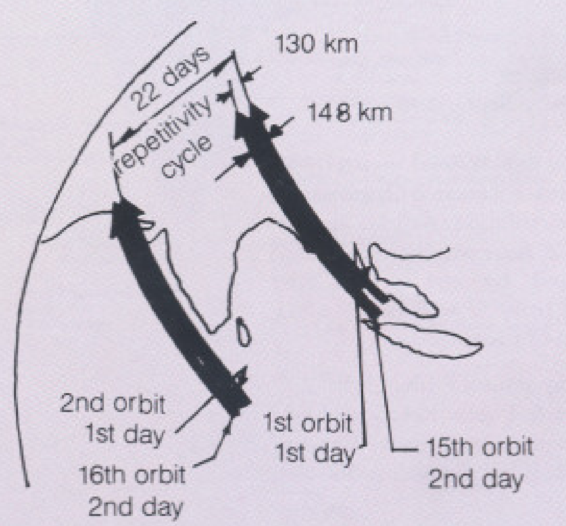


Illustration of the pushbroom scan technique

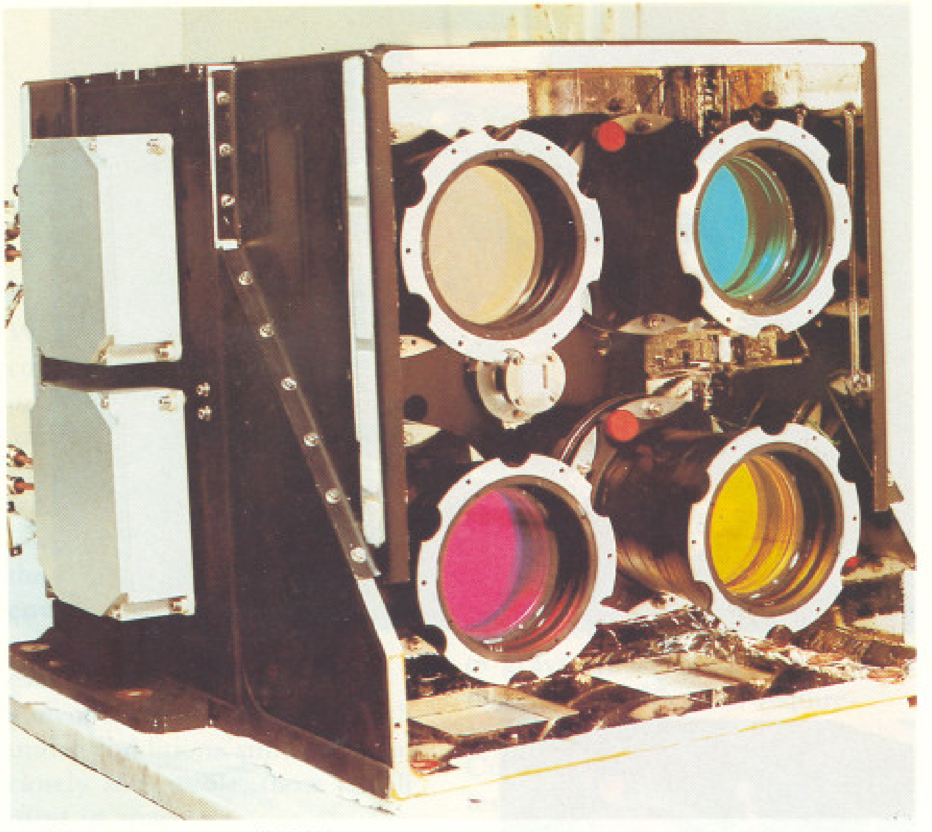
IRS Orbital coverage characteristics



approach has the advantages of maximising the exposure time for each ground point and ensuring excellent photogrammetric quality along the line scan axis.

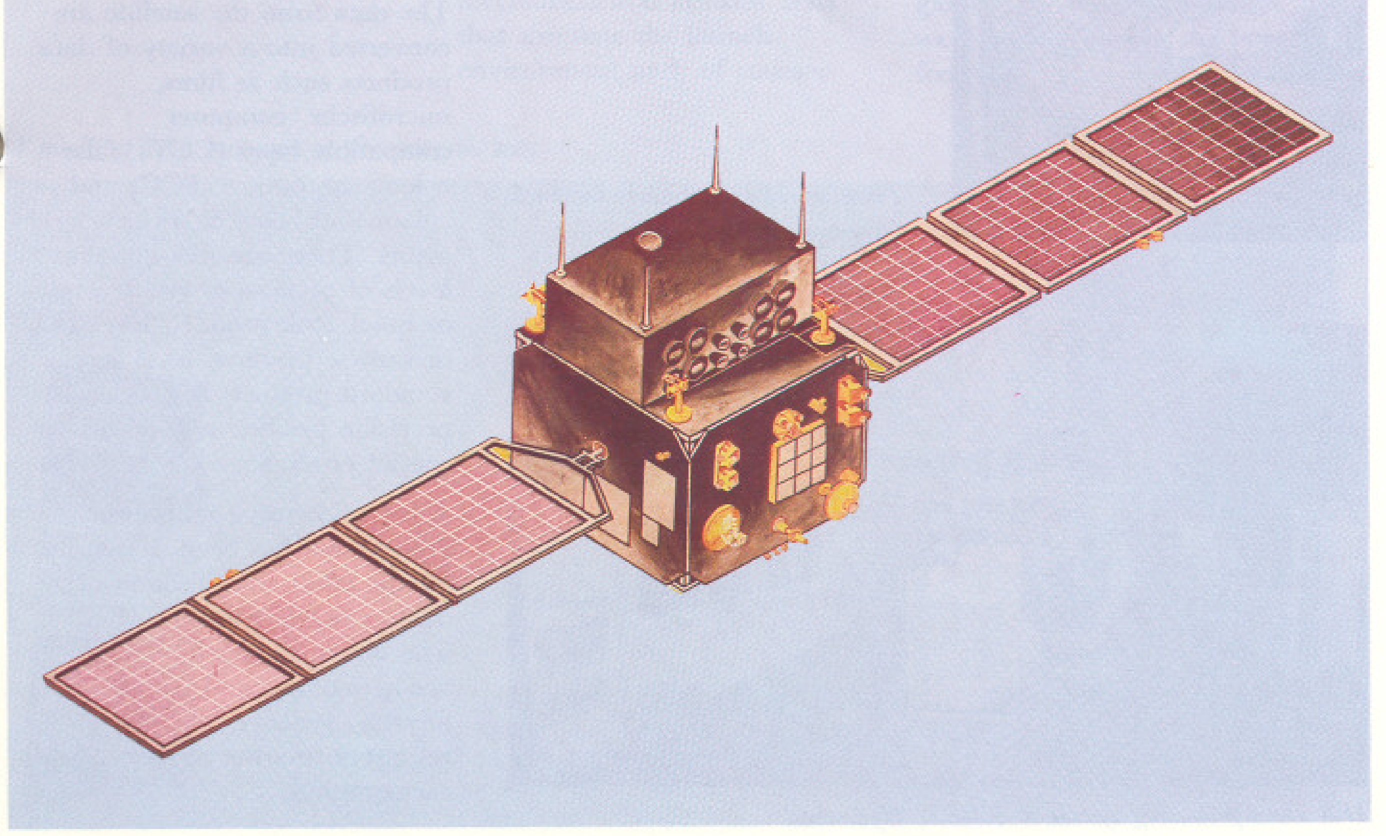
Each of the three cameras provides data in four spectral bands, three of which are in the visible region and the fourth in the near IR. One of the three cameras, designated LISS-I, provides a spatial resolution of 73m. The other two, LISS-IIA & LISS-IIB, provide a resolution of 36.5m. LISS-I has a swath of 148 km whereas the same width is realised by the combined swath of the two LISS-II cameras.

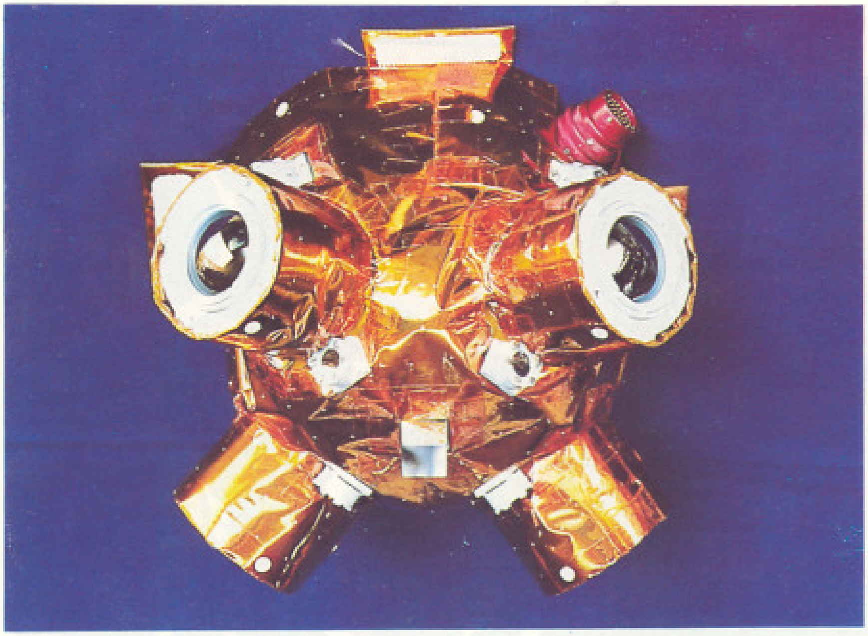
The satellite mainframe is configured to provide adequate flexibility to reconfigure the payload for future missions.



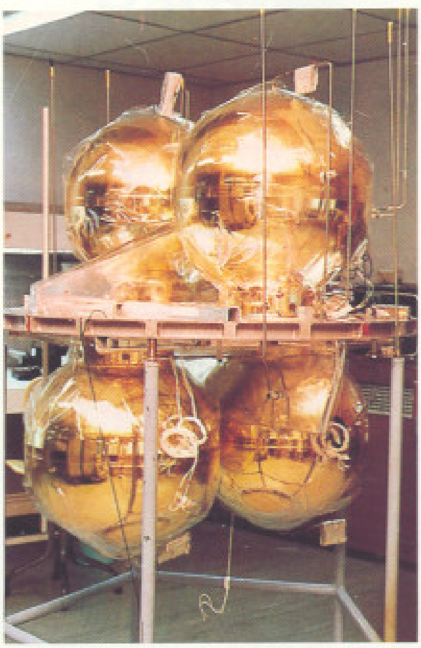
LISS camera system of IRS

An artist's impression of IRS in the fully deployed condition





Static Horizon Sensor for IRS



Titanium alloy fuel tanks mounted on central deck of IRS

IRS Data processing system at NRSA, Hyderabad

The thermal control system employs both passive and semi-active elements such as paints, thermal blankets and heaters. The power system consists of deployable solar arrays stowed on either side of the satellite along the pitch axis, each containing three panels capable of providing 540 watts power at the end of life. The attitude control system consists of earth and sun sensors, a redundant dry tuned gyro system and a set of four reaction wheels, along with the required electronics for maintaining the satellite in a 3-axis mode.

While the IRS Mission Operations Control Centre is located at Bangalore, the data reception facilities are at the Shadnagar station of the National Remote Sensing Agency (NRSA), Hyderabad. The Shadnagar station has capabilities for acquiring imageries in the X- and S-bands as well as provisions for quick-look display of data from a selected camera.

The data from the satellite are converted into a variety of data products such as films, microfische, computer compatible tapes (CCT), false colour composites (FCC) and colour and black & white prints. There are five different levels of processing viz. level 0 or quick-look product, level 1 or browse product, level 2 or standard product, level 3 or precision product and level 4 or special product.

A comprehensive utilisation programme has been drawn up for the effective utilisation of data available from the IRS. The major application areas are agriculture and land use, forestry, geology, water resources, marine resources and cartography□

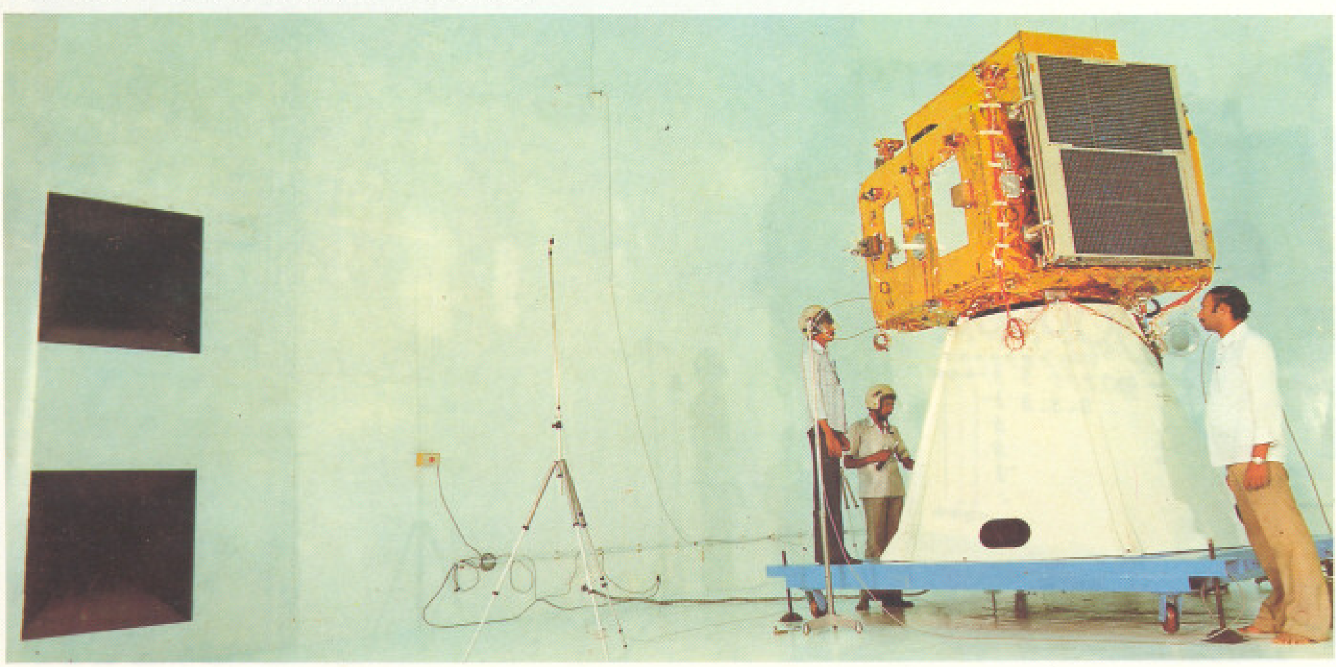
Testing to Last a Life Time

Whatever the purpose, be it for communication, remote sensing or scientific research, a satellite and its payload must withstand first the extreme stresses they will be subjected to during launch and then, once in orbit, the rigours of the space environment. There is only one way of making sure of this: every single element of the system must be tested on earth under conditions simulating, as closely as possible, those it will meet in space.

IRS-1A is no exception to this rule. The structural, thermal and engineering models of the satellite went through a series of such tests during the last year or so. Among the most demanding of such tests are the mechanical and acoustic tests that simulate the launch environment and, of course, the solar simulation tests which simulate the vacuum, heat and solar radiation conditions of space.

The structural model of IRS with all major structural components of flight quality and subsystems simulated for their interface, mass and centre of gravity was tested for dynamic qualification requirements of the launcher. Comprising sine and shock tests along pitch, roll and yaw axes, these tests were carried out at the vibration laboratory of ISRO Satellite Centre (ISAC), Bangalore. The satellite model was instrumented with over 80 accelerometers and 10 strain gauges for response measurements and the global spacecraft frequencies were found to meet the frequency constraints imposed

A model of IRS being set up for acoustic tests

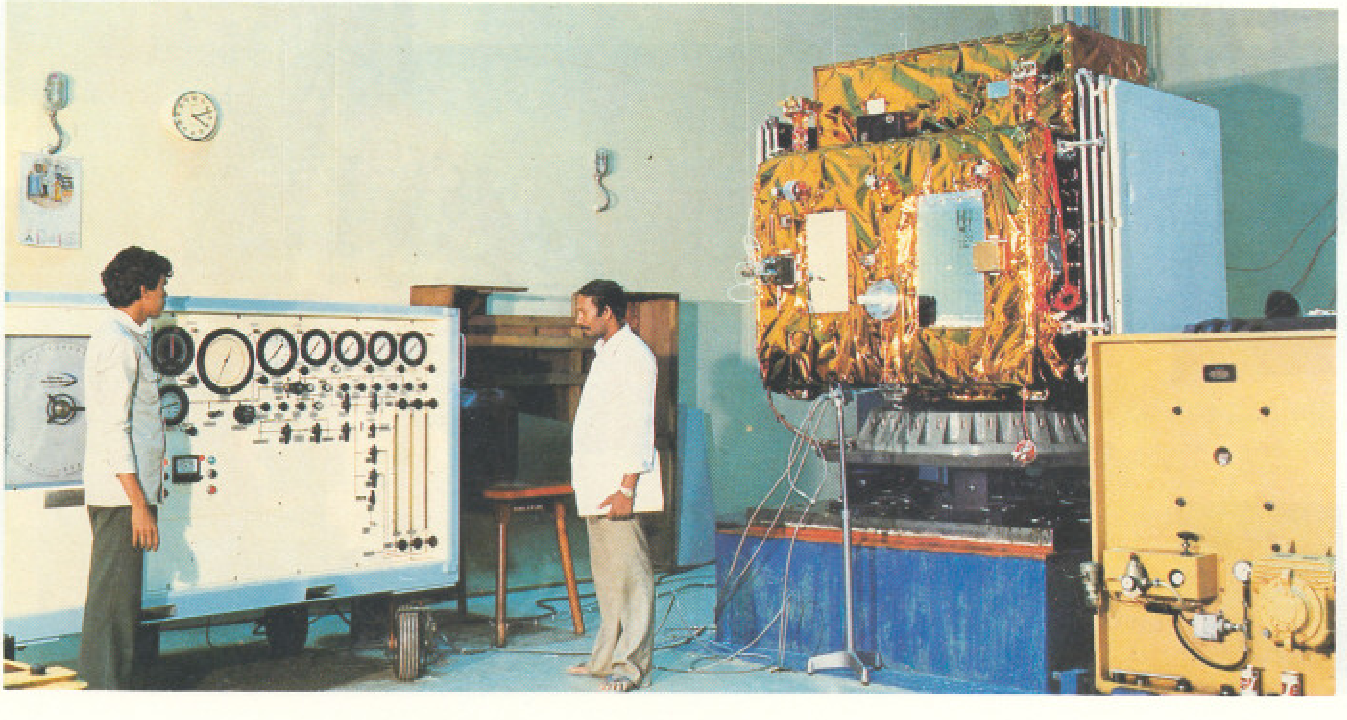


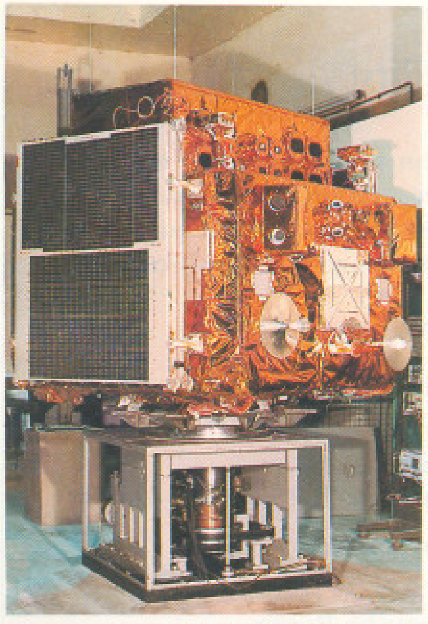
by the launcher characteristics.

Thermal design of IRS-1A was evolved through detailed mathematical modelling. The test philosophy adopted for thermal qualification consists of two parts: First a thermal balance test by simulating the solar absorbed load and second, a solar simulation test. While the initial heater-pad test was conducted at the 4m thermal vacuum chamber at ISAC, the solar simulation test was carried out at INTESPACE, France. This was because the ISAC facility is not yet fitted with a solar simulator. In both the tests hundreds of thermal sensors were used to measure the temperature distribution and to evaluate the thermal design. The 14-day long solar simulation test, in particular,

Moment of Inertia Measurements being carried out on the Engineering model of the IRS

Fuel loading test being carried out on a model of IRS

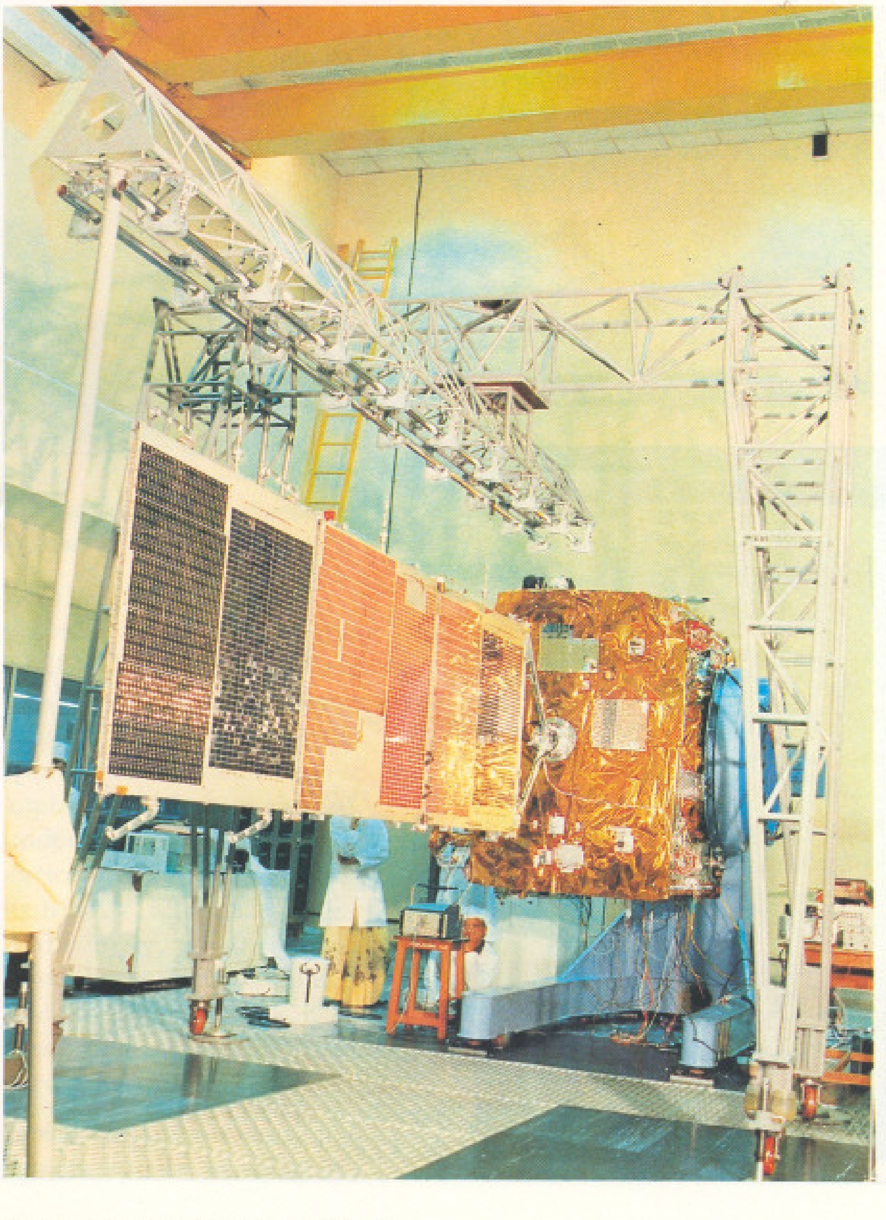




Engineering model of the IRS undergoing dynamic balance tests

provided sufficient data for verification of the thermal design of the system under conditions very similar to those expected in space.

With the advent of longer and very powerful launch vehicles the necessity to test the ability of spacecraft components to survive high intensity acoustic environment has become more important. The engineering model of IRS-1A in its full launch configuration, was subjected to such a test at the newly built Acoustic Test Facility (ATF) of the National Aeronautical Laboratory (NAL), Bangalore. In addition to verifying the electrical performance of the system on exposure to the acoustic environment dictated by the launcher specifications, the tests also confirmed the satisfactory functioning of the solar array deployment mechanism, alignment stability of the payload etc. With the completion of these tests the fabrication of the flight spacecraft started and is in progress□



Solar Panel deployment tests of IRS

ISRO-NAL Acoustic Test Facility

The high velocity gases that emanate from the rocket engines produce turbulence when mixed with the ambient air and give rise to pressure fluctuations resulting in acoustic noise. As much as 0.5 to 1% of the energy involved in the exhaust gases is transformed into acoustic energy and is transmitted back to the space vehicle.

In addition, aerodynamic effects in the transonic region, unsteady engine operations, separation flows, shock instability, structural protrusions etc., also produce acoustic noise.

Design evaluation and environmental qualification for high intensity noise are essential for both spacecraft and launch vehicle systems. Failure may arise due to fatigue, wear and malfunction of sensitive components. In general, structural parts for which the ratio of surface area to mass is large are particularly susceptible to acoustic failure. Thus, components mounted on such areas may experience debonding or contact failures.

To simulate such a flight environment realistically, it is necessary to have an acoustic test facility of adequate size. Considering the large air flow requirements needed for this, ISRO decided to utilise the existing air supply facilities at the Wind Tunnel Centre of the National Aeronautical Laboratory (NAL), Bangalore. Accordingly a Memorandum Of Understanding (MOU) was signed between ISRO and NAL to realise an acoustic test facility at the NAL campus.

This way it was possible to save on the cost of large air compressors, storage vessels and flow control equipment.

The stringent needs relating to the supply of clean air to the noise generator, pneumatic systems for pressure and flow controls etc., made the construction of the ATF a truly challenging job. The facility, however, was completed in time for full-fledged tests on the Stretched Rohini Satellite Series (SROSS) and IRS satellites. Considered to be one of the largest such facilities in the world, the ATF consists of a 1100 cu.m reverberation chamber capable of providing an overall sound pressure level of 155 db. It has a host of auxiliary facilities such as test item unloading area, test item preparation area, class 100,000 clean room, data acquisition centre and a control room□

SPECIFICATIONS

Volume of chamber
1100 cu.m

Dimensions
10.33 × 8.2 × 13m

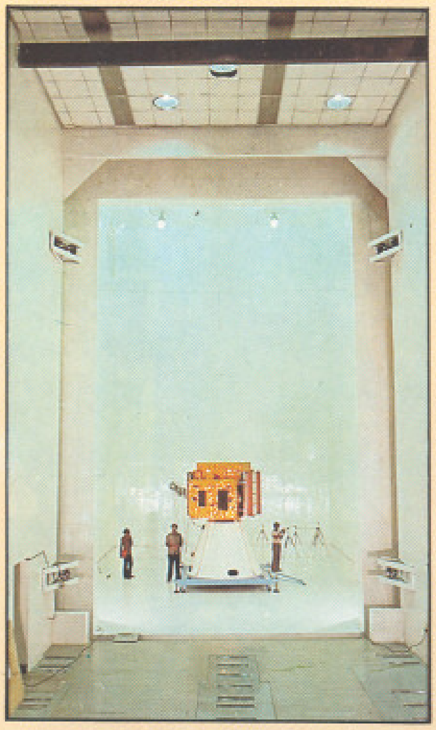
Door size
6 × 10m

Acoustic Power
80 kW

OASPL
155 db

Frequency Range
13.5 - 10,000 Hz

Maximum run time
8 min.



A model of the IRS Satellite inside the ATF

An Interview with Dr. K. Kasturirangan

Sometime ago ***Countdown,*** *the house journal of the Vikram Sarabhai Space Centre (VSSC) at Trivandrum, interviewed Dr. Kasturirangan, Project Director, IRS. Excerpts:*

Q: *Can you briefly describe the mission of IRS?*

A: The IRS represents probably the first experiment by ISRO in the field of remote sensing with a space segment to provide specific services to specific users. The main application areas envisaged under the IRS project are: agriculture, forestry, geology, hydrology, and land use. Accordingly, we are planning to deploy a 3-axis-stabilized satellite into a polar sun-synchronous orbit and operate it routinely.

It will carry an operational camera system working in visible and near infrared. Operated routinely, it would have resolutions which are compatible with the intended applications. In fact we have practically two levels of resolution, 35m and 70m. IRS is expected to routinely provide to the users data service in the areas mentioned above through reception of data on a ground segment which is being set up at the NRSA for receiving, processing and disseminating the information.

Q: *Can you add a few more details on the system?*

A: Till date, IRS is the heaviest satellite of ISRO. It weighs over 950 kg including 80 kg of hydrazine. There is some possibility for bringing down the weight; but this will be the sort of upper limit for the weight. The satellite derives its power from deployed solar panels of size, something like 7.5 sq.m. About 650 Watt power it will generate routinely, and is backed up by two 40 AH nickel-cadmium batteries which will support the operation of the payload in the peak mode; this is needed because the payload operation cannot be sustained by the solar panel power output alone. Then, it has a telemetry system operating in the S-band for monitoring the health of the satellite; the tracking system, built around S-band again, will help determine the position of the satellite. Then there is the command system which can carry out something like 511 on-off commands, though we will use something like 350 commands only for the operations. Data from the two basic payloads — incidentally, the two camera payloads with 70m and 35m resolutions are state-of-the-art payloads — will be transmitted through S- and X-bands normally allotted for transmission of data from remote sensing satellites. The data rates from these payloads will be about 10.2 megabits from each of the high resolution payloads. So, that will add up to about 20.4 megabits per sec. The satellite, of course, will be put into a polar sun-synchronous orbit because we would like to make the observations under constant solar illumination conditions. The orbit will be at an altitude of 904km and with a period of roughly 103 minutes. With this kind of an orbit the satellite can revisit the same location on the earth every 22 days; this orbit will also ensure that the satellite crosses the equator every day precisely at the same local time. For the IRS this is fixed at 10 AM.

Q: *The heart of any remote sensing payload is the sensor. Are we developing the sensors indigenously?*

A: We are building the total system, i.e., we are doing the systems engineering, design, and also building several elements of the payload and assembling a few things which we are getting from abroad. The heart of the whole payload system is a charge coupled device sensor which is a 2048-element CCD operating in the visible and near infrared. This of course is being procured from outside. The system is operated with the suitable optics — a linear array using both the concepts of electronic scanning and the forward motion of the satellite — what they call as the pushbroom sensor. And this kind of a system is for the first time being used by us in IRS. Besides IRS the French remote sensing satellite SPOT also is using the same technique.

Q: *How far is this payload compatible with PSLV?*

A: Yes. This is one of the important criteria we have taken into account in the design of the satellite. The PSLV capabilities of course are known: 1000 kg and 900 km orbit. So you will see that the 'statistics' of the satellite roughly compare with this; it can be accommodated within a shroud dimension of something like 2.4m. You have a much bigger shroud dimension than this for PSLV; so, that should pose no problem.

Q: *Besides the development of hardware for the IRS, are any other studies being carried out to support the remote sensing efforts?*

A: Yes. In remote sensing there is still quite a large number of complex scientific problems to be solved before we could fully exploit the technology. One could start with solar radiation, its transmission through the atmosphere, including scattering and absoprtion properties, the reflectance properties of the target in the visible, reflectance properties of the objects in the microwaves, or emission properties in the thermal infrared. ISRO is trying to encourage some of these studies through sponsored research programmes in the academic institutions. ISRO itself is trying this. This represents one set of activities. The second is a bit more direct, i.e. you do experiments to directly study the 'signature'. You put a spectral radiometer on the ground and under different solar illumination conditions, you study the radiance pattern of various objects on the ground. So you can actually collect the data and have a signature-bank. The third aspect is image interpretation and analysis using computer systems.

There is a considerable amount of interest now to undertake this approach, which is a little bit more advanced than the earlier approach of using a simple photo-interpretation. This is what they call digital processing of data. In order to support this activity ISRO is setting up five Regional Centres for remote sensing, where the users could get themselves familiarised with the methods of photo-interpretation and the digital analysis of the data. There will be computer facilities manned with people who give them (the users) software system support, and after having learnt this, the users can transfer this knowledge to others in their parent organisation.

Q: *How does the Project manage the liaison with the users?*

A: The IRS Project doesn't directly deal with the user agencies. The ISRO-IRS Utilization Project does this. It is a separate project by itself and is managed by ISRO in close liaison with the user agencies. They have, in turn, identified several projects with the user agencies at four levels — the operational projects, the quasi-operational projects, the experimental projects, and the technique development projects. Under each of them, depending on the maturity of the application and the user preparedness, specific areas have been identified. Thus the project on land use is at the operational level while agriculture is really on the quasi-operational level because, as you know, mostly they are going to work on crop acreage and crop identification, but crop yield forecasting is going to be at experimental level. ISRO has also established an Earth Observation Office at ISRO Headquarters, which acts as the focal point for all the issues related to interactions with the users. This office helps the users by providing them guidance. And then you have also the National Natural Resources Management System, (NNRMS).

Q: *After all, remote sensing can be done using aircraft. So how do you justify going in for a sophisticated spacecraft system?*

A: This question of aircraft vs. spacecraft for remote sensing has been often debated. The basic difference is that when you go to higher altitudes, you have the advantage of a synoptic view; then again repetitiveness of observation is possible with spacecraft. Moreover in spacecraft you use the same sensor, which was calibrated once, to continuously get the data. Thus you avoid the intercalibration problems. With satellites you also have a quick turn-around time for coverage. So these are some of the obvious advantages in going for satellite remote sensing. Aircraft, of course, have the advantage that for the same type of camera you get a much better resolution, much better details and much

Spectral Bands chosen for the IRS-1 Cameras

Band	Spectral range	Remarks
1	0.45-0.52	Coastal environment studies, chlorophyll absorption region
2	0.52-0.59	Green vegetation, useful for discrimination of rocks and soil for their iron content
3	0.62-0.68	Strong correlation with chlorophyll absorption in vegetation, discrimination of soil and geological boundaries.
4	0.77-0.86	Sensitive to green biomass, opaque to water resulting in high contrast with vegetation.

Summary Characteristics of the IRS-1 Orbit

	Parameters
Repetition cycle	22 days (307 orbits)
Orbit height (km)	904
Inclination (deg)	99
Period (min)	103
Orbit decay (m/day)	6
Orbit correction cycle (days)	75
Swath (km)	
Low resolution camera	148
Medium resolution camera	2 × 74
Image overlap at the equator	9.4%

Specifications of IRS-1 Payloads

Item	Specifications	
	LISS-I	LISS-II
Focal length (mm)	162	324
FOV	9.4°	4.7° + 4.7°
IFOV (microrad)	80	40
No. of elements of CCD	2048	2048
Ground resolution (m)	73	36.5
Spectral range (μm)	0.45-0.86	0.45-0.86
No. of spectral bands	4	4
Swath (km)	148	74 × 2
Radiometric resolution	128	128
Data rate (mbps)	5.2	2 × 10.4

Mission Parameters of IRS-1

Orbit type	:	Circular sun-synchronous
Orbit altitude	:	904 km
Orbit eccentricity	:	0.002
Local time of pass	:	10 AM
Coverage cycle	:	22 days
Swath	:	148 km (LISS-I) 145 km (LISS-II)
Geometric resolution	:	72.5 m (LISS-I) 36.25 m (LISS-II)
Spectral range	:	0.45 - 0.86 μm in 4 bands
Radiometric level	:	7 bits

Spacecraft Characteristics

Mass	:	960 kg
Size	:	1.6 × 1.56 × 1.1 m
Thermal control	:	Semi-active using heaters, tapes, MLI blankets, paints and OSR.
Pointing accuracies (3σ)	:	±0.4° for pitch and role ±0.5° for yaw.
Jitter (3σ)	:	1/10 pixel
Drift rate	:	6.25×10^{-3} in 11 seconds
Solar array power	:	709 watts (for normal incidence)
Battery	:	2 × 40 AH
TTC frequency	:	S band and additional uplink in VHF
H/K bit rate	:	256 bits/sec.
No. of data commands	:	21
Data handling system	:	X band QPSK for LISS-II S band BPSK for LISS-I

narrower swath. But basically the question is one of logistics. For example, the IRS covers the whole of the Indian subcontinent in just 22 days. If you were to translate this in terms of an aircraft-based survey I just would not know how many tens of years it would take! And then you have to reckon with problems of solar illumination and other problems which are very difficult to control when you have an aircraft-based survey. Aircraft are used effectively in what is known as multi-stage remote sensing. In this concept the data from spacecraft is used for gross-level identification while for some specific points aircraft data is obtained for better detail. Using then the ground-truth information, finer details can be culled out from the data pertaining to any specific area.

Q: *What is the extent of participation of agencies outside ISRO, in the IRS Project?*

A: In the development of the space segment and many elements of the ground segment, as is the normal policy with ISRO, we have tried to make use of the industry's support wherever it is available. The entire mechanical structure for the spacecraft is fabricated by the Hindustan Aeronautics Limited, Bangalore. Then we have support from Bharat Electronics Limited. They give us some critical things like printed circuit boards and so on. Some elements for the ground stations of ISRO Telemetry, Tracking & Command Network (ISTRAC), which will be used by IRS are also being designed and built at the Bharat Electronics Limited. There are several such public and private agencies also, who give us substantial support□

On the SPOT Satellite Data

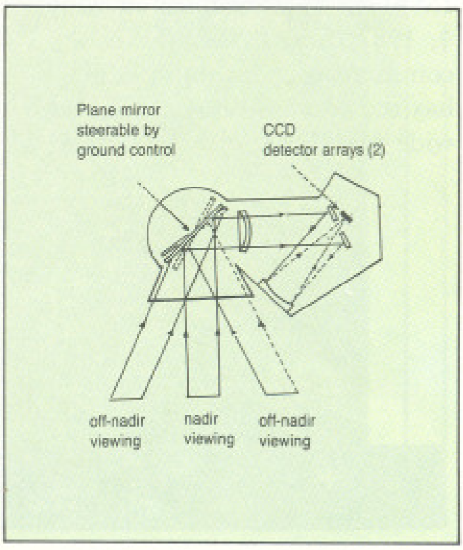
The National Remote Sensing Agency (NRSA) has facilities to receive remote sensing satellite data at its earth station at Shadnagar, near Hyderabad. Established in 1979 this earth station has been regularly obtaining the Multispectral Scanner (MSS) and the Thematic Mapper (TM) data from the American Landsat Series of satellites. Data from the Advanced Very High Resolution Radiometer (AVHRR) of the NOAA series of meteorological satellites are also received at this station. These have been of immense use in the satellite-based resource survey projects in the country. The applications include land use, forestry, soil studies, urban area mapping, cartography and a host of others.

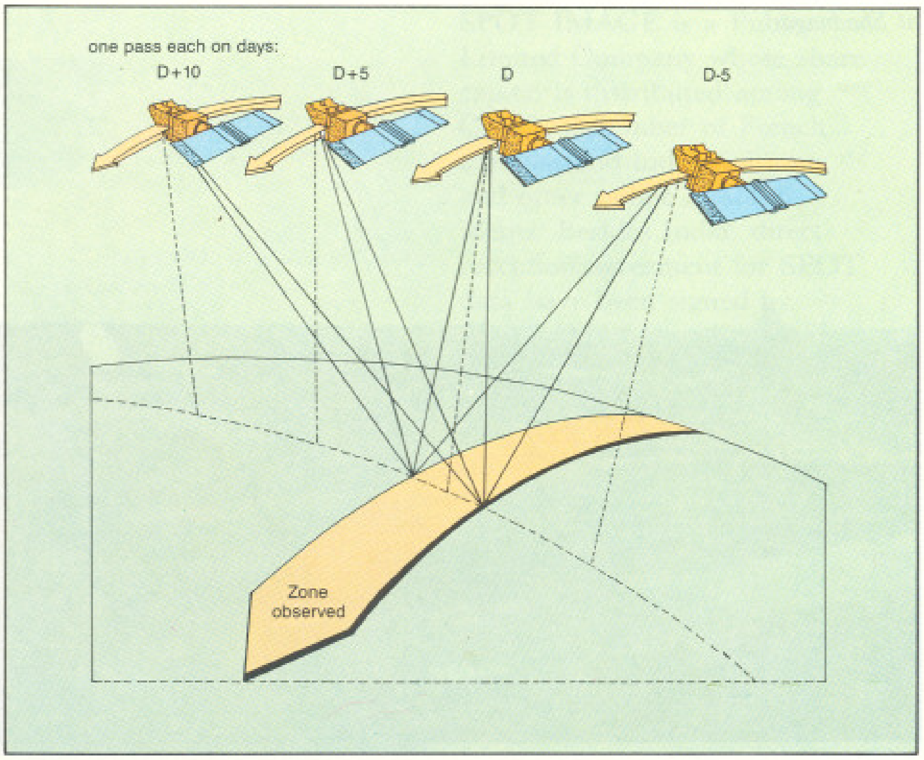
While the two terminals at Shadnagar station are being upgraded for reception of data from the Indian Remote Sensing Satellite (IRS), one of them recently started routine reception of data from the French 'SPOT' satellite.

SPOT is an earth observation satellite launched by the French national space agency, CNES (Centre National d'Etudes Spatiales), on February 22, 1986. The satellite carries two identical sensors on board each having a swath width of 60 km. SPOT operates in two modes, multispectral and panchromatic. One of the key features of the SPOT is the steerable mirror which provides off-nadir viewing capability.

This technique provides a quick revisit capability on specific sites. In other words, during the nominal 26-day period separating two successive satellite passes over a given point on the earth's surface, the point in question could be observed on seven different passes if it were on the equator and on 11 if at a latitude of 45°. Another important possibility offered by off-nadir viewing capability is that of recording stereoscopic pairs of images of a given scene. This three-dimensional capability provides additional terrain height information which will significantly enhance the use of satellite data for a variety of applications such as cartography, geology and geomorphology.

Off-nadir viewing and revisit capabilities of SPOT





It is only natural that results of such advanced capabilities as high resolution, off-nadir viewing and stereo imaging are made available to the resource planners of the country. Besides these direct applications, this arrangement provides us hands-on experience in organising our country's satellite-based resources survey and management system.

The reception of SPOT data at NRSA has been made possible through an agreement signed between the NRSA and the French Company, SPOT IMAGE, at Bangalore on May 4, 1987. SPOT IMAGE is a commercial corporation which has the responsibility for worldwide marketing of SPOT data.

Prof. B.L. Deekshitalu, Director NRSA (left) and Dr. G. Brachet, Chairman, SPOT Image exchanging the SPOT reception agreement signed in Bangalore.

A view of the NRSA earth station at Shadnagar

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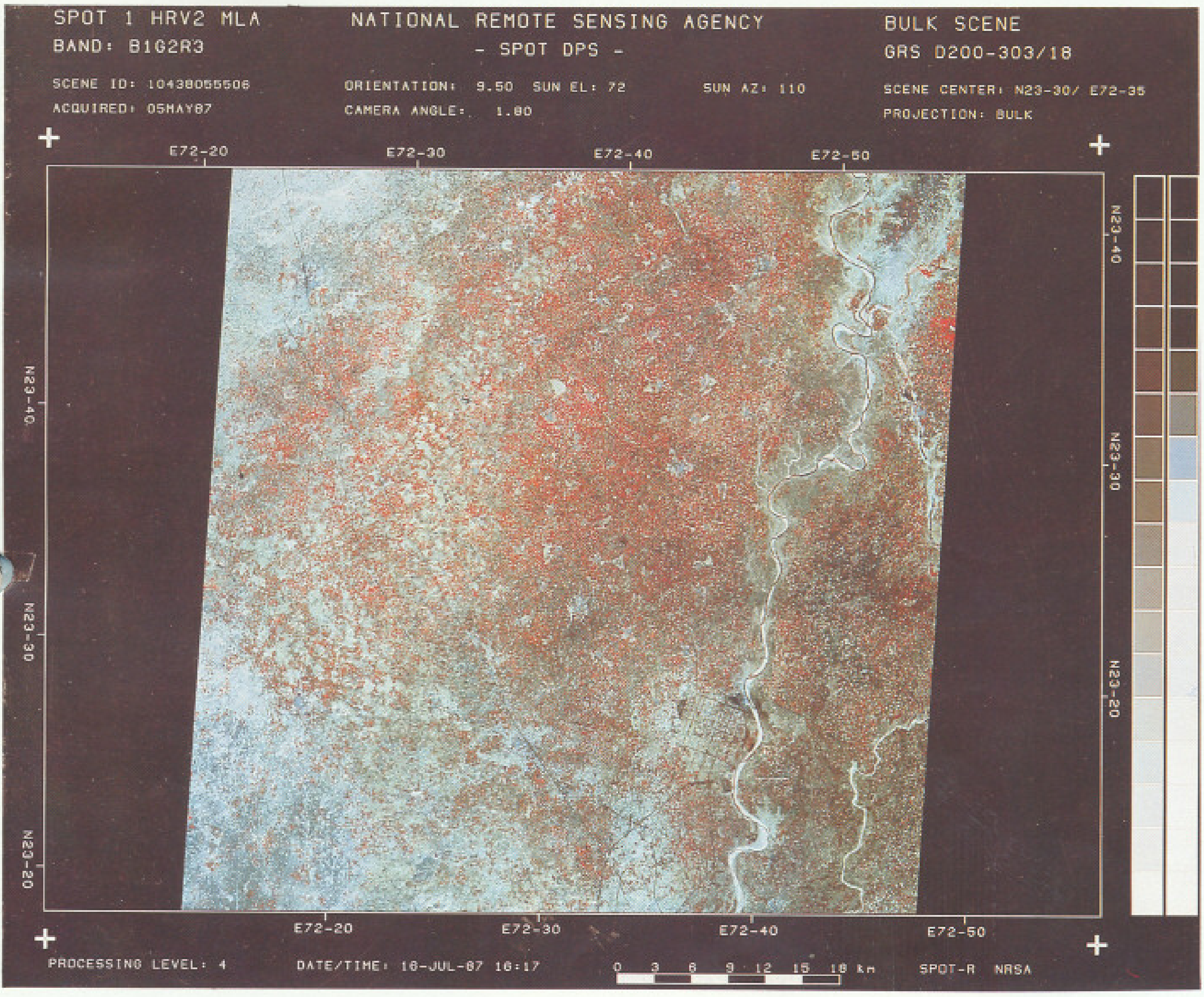
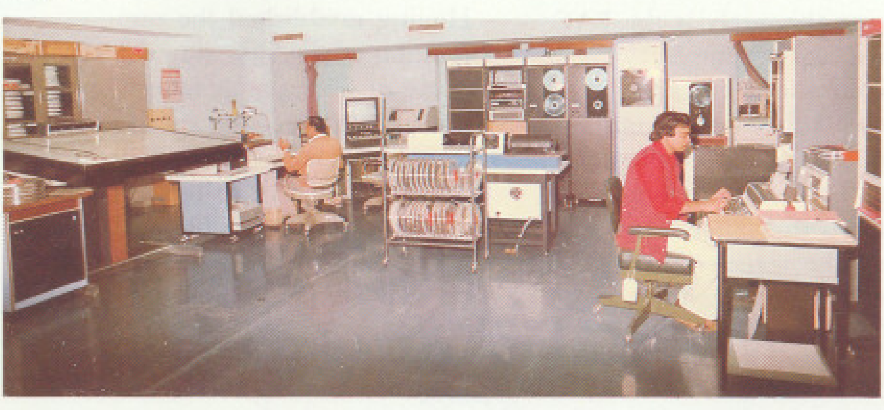


Bulk corrected false colour composite scene in the scale of 1:400,000. Gandhinagar along the river Sabarmati is shown in this scene received from SPOT and processed at NRSA.

Satellite data processing facility of NRSA



SPOT IMAGE is a Public Limited Company whose share capital is distributed among CNES, a number of French banking and industrial units and other public establishments. Besides India, direct reception agreement for SPOT data have been signed by SPOT IMAGE with several countries including Canada, China and Japan. Like India, Canada has also started reception of SPOT data□

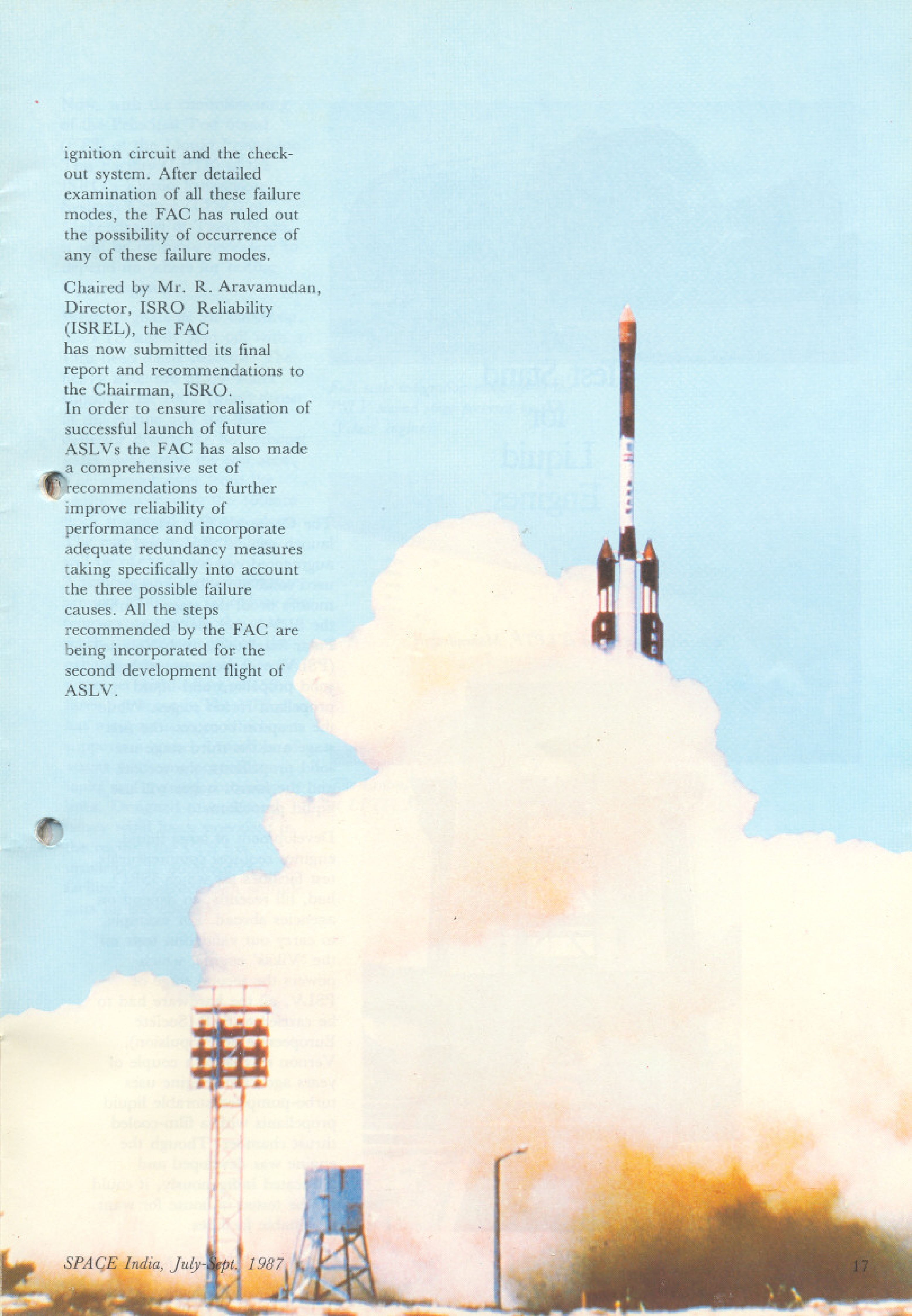
ASLV-D1 Failure Analysis

After an exhaustive and indepth analysis of all flight data and extensive simulation studies, the ASLV-D1 Failure Analysis Committee (FAC) has concluded that the failure of the March 24 ASLV mission was primarily due to non-ignition of the first stage motor; and that the non-ignition of the motor could only be explained by an extremely small but finite probability of: (a) inadvertent short circuit in both the ignition circuits; (b) inadvertent electrical open circuit in both the ignition circuits and (c) random malfunction of safe-arm device. The findings of the FAC are based on detailed analysis of the voluminous data obtained in the D1 flight.

During the analysis the FAC constituted seventeen subcommittees to carry out indepth studies and conduct investigative and confirmatory tests. The failure analysis confirms that after a perfect lift-off the vehicle had functioned nominally up to 48.74 sec, and that thereafter the first stage did not ignite even though the ignition command was sent by the on board computer, thereby causing loss of control of the vehicle. The strapon motors separated even under this adverse environment at the intended time of 52.2 sec. However, the large aerodynamic loads experienced by the vehicle due to loss of control resulting from the non-ignition of first stage caused the severance of the vehicle at the interface between the second and the third stages at 52.41 sec. The third stage has ignited at the intended time of 156.8 sec. and performed nominally till the splash down at 164 sec. after launch.

Having established the non-ignition of the first stage as the cause of failure, the failure analysis efforts were specifically focused on the regime of flight up to 50 sec. An exhaustive list of thirty seven possible failure modes was identified in the areas of igniter, safe-arm unit, ignition circuit and the check-out system. After detailed examination of all these failure modes, the FAC has ruled out the possibility of occurrence of any of these failure modes.

Chaired by Mr. R. Aravamudan, Director, ISRO Reliability (ISREL), the FAC has now submitted its final report and recommendations to the Chairman, ISRO. In order to ensure realisation of successful launch of future ASLVs the FAC has also made a comprehensive set of recommendations to further improve reliability of performance and incorporate adequate redundancy measures taking specifically into account the three possible failure causes. All the steps recommended by the FAC are being incorporated for the second development flight of ASLV.



A Test Stand for Liquid Engines

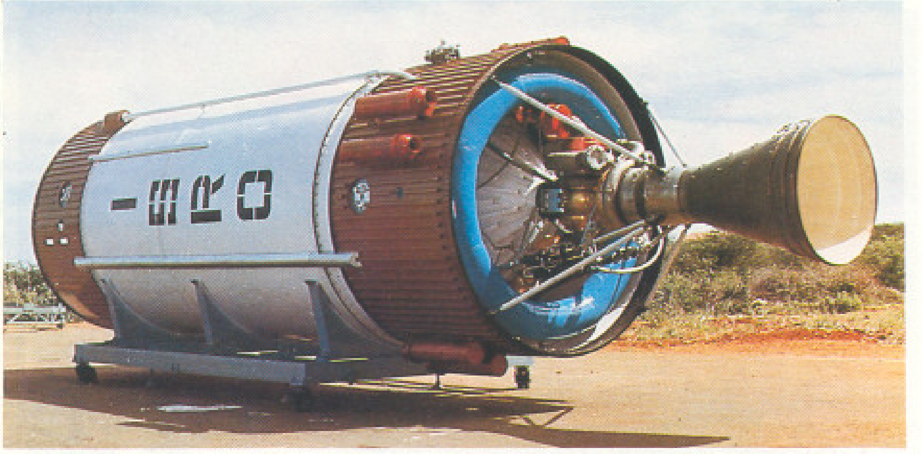
The principal test stand at LPTF, Mahendragiri

The Country's first satellite launch vehicle SLV-3 and its augmented version, ASLV, used solid propellant rocket motors in all the stages. Unlike the SLV-3 and the ASLV, the Polar Satellite Launch Vehicle (PSLV) will make use of both solid propellant and liquid propellant rocket stages. While the strap-on boosters, the first stage and the third stage use solid propellants, the second and the fourth stages will use liquid propellants.

Development of large liquid engines requires commensurate test facilities for which ISRO had, till recently, to depend on agencies abroad. For example, to carry out validation tests on the 'Vikas' engine, which powers the second stage of PSLV, all the hardware had to be carried to SEP (Sociéte Europeenne de Propulsion), Vernon in France a couple of years ago. This engine uses turbo-pump-fed storable liquid propellants with a film-cooled thrust chamber. Though the engine was developed and fabricated indigenously, it could not be tested in-house for want of suitable facilities.

Now, with the commissioning of the Principal Test Stand (PTS) at the Liquid Propulsion Test Facility (LPTF) of the ISRO's Liquid Propulsion Systems Centre (LPSC) at Mahendragiri in Tamil Nadu, it will be no more necessary to depend on others for testing liquid engines.

Western ghats as the backdrop, the PTS stands 30m tall with a 13m deep flame detector. The heavy structure of the stand supports the 100T (max) thrust of the engine and the flame deflector diverts the hot exhaust gases away from the test area. The exhaust gases from the engine impinge on the 100mm thick staggered deflector plates. The exit velocity of the gas, will be of the order of 2.5km/sec and the temperature, around 1500° C. To reduce the temperature, before the gases reach the deflector plates, the exhaust gases are cooled by a water jet with a flow of 150 litres per second. The PTS also has a superstructure which supports a crane, a number of access platforms propellant tanks and myriad plumbing lines. Designed to withstand heavy wind loads prevalent in the region, the PTS has provisions to augment the facility to conduct high altitude tests on the engines□



Full scale integration mock-up of the PSLV second stage powered by the 'Vikas' engine

The Central data processing facility at LPTF, Mahendragiri

Indo-Soviet Collaboration in

Space Meteorology and Aeronomy

An important item in the itinerary of any visitor to Trivandrum is a trip to the Thumba Equatorial Rocket Launching Station (TERLS) to witness a rocket launch - if he happens to be there on a Wednesday, that is. For every Wednesday since December 1970, an M-100 rocket is launched from the TERLS range of ISRO.

A soviet M-100 meteorological rocket getting ready for launch from TERLS

M-100 is a Soviet rocket used for meteorological investigations jointly by the Soviet and Indian Scientists. The weekly launches provide data on the temperature and winds in the middle and upper atmosphere.

This collaborative programme is carried out under a Memorandum of Understanding signed between the Indian Space Research Organisation (ISRO) and the USSR State Committee on Hydrometeorology and Control of Natural Environment (SCHCNE). Under this MOU a variety of scientific experiments is planned by seven Theme Groups comprising specialists from both the countries. Besides, the scope of the MOU also includes investigations of upper atmospheric processes using the Indian Rohini rockets. The Theme Group proposals are examined by the ISRO-SCHCNE Joint Working

Group during their annual meetings.

One such meeting of the Joint Working Group was held during May 28-30, 1987 at ISRO HQ, Bangalore. The progress made so far in the joint experiments as well as the plans for the future were reviewed by the Joint Working Group. This meeting was preceded by a workshop on the results of the ISRO-SCHCNE collaborative experiments in space meteorology and aeronomy. Thirteen presentations were made in this workshop, which was attended by Soviet and Indian scientists. The presentations covered themes relating to climatological models of the atmosphere, Ozone intercomparison, D-region profiles, mass spectrometric experiments, long and short period energy fluxes and stratospheric warming events.

Later the nine-member Soviet delegation led by Prof. V.M. Zakharov, Vice Chairman, SCHCNE met Prof. U.R. Rao, Chairman, ISRO and signed a protocol for the continuation of the activities☐

A M-100 pay load being assembled at TERLS

The Themes of ISRO-SCHCNE Collaborative Investigations

☐ Identification of climatic norms and variability for the middle atmosphere.

☐ Study of different sources of energy in the equatorial and tropical regions of the middle atmosphere and mechanism for energy transport.

☐ Establishing empirical relations between variations of the middle atmosphere parameters in the equatorial and tropical regions and characteristics of solar activity, comparison with middle and high latitude data.

☐ Investigation of parameter variations of upper atmosphere and equatorial ionosphere between 80-300 kms.

☐ Investigations of irregular structure of the equatorial ionosphere.

☐ Development of methods for remote sensing from polar orbiting meteorological satellites.

☐ Integrated studies of height profiles of electron density and collison frequency in the equatorial ionosphere to construct a low latitude ionospheric model.

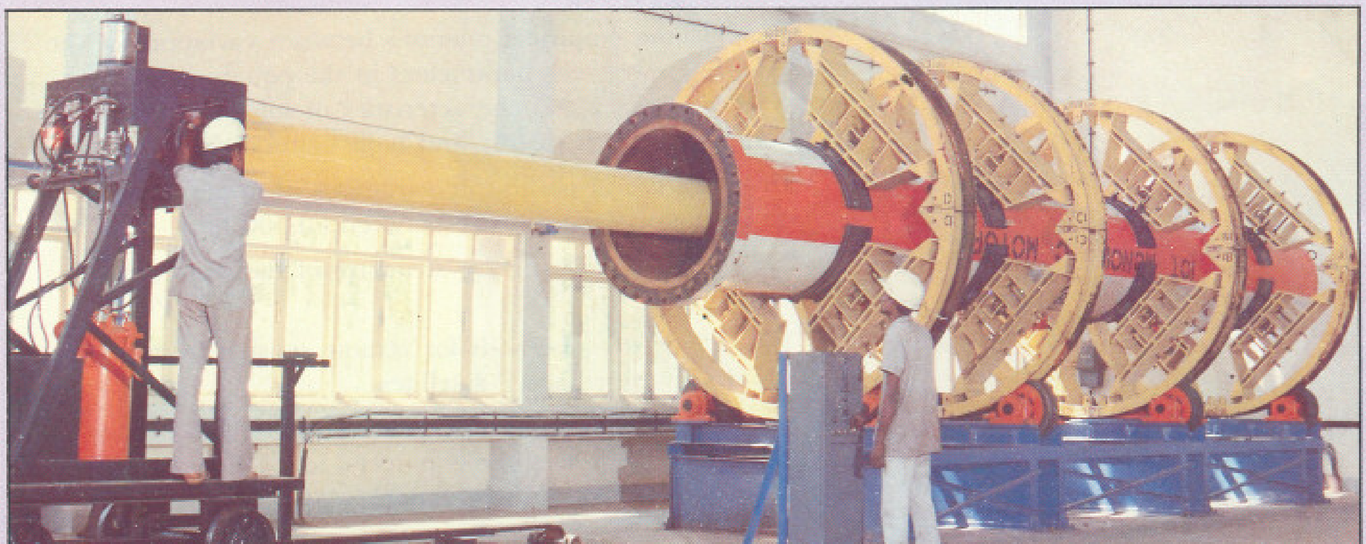
Prof. R.P. Rastogi, Vice Chancellor, Banaras Hindu University and Chief Guest, SPEAR-87 presenting a momento to Shri M.R. Kurup, Director, SHAR Centre in appreciation of his contributions to Rocket Propellant Technology

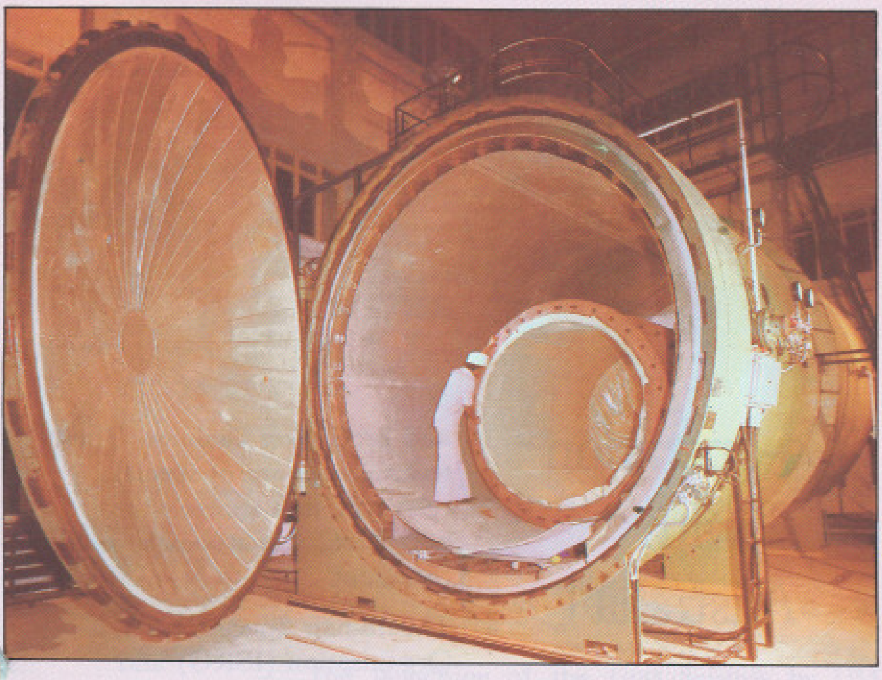
SPEAR - 87

Solid Propellants for Explosives and Rocketry (SPEAR) was the theme of a symposium held at the SHAR Centre at Sriharikota during May 5-6, 1987. Organised under the auspices of the Indian Space Research Organisation (ISRO) and the High Energy Material Society of India (HEMSI), this symposium provided an excellent forum to take stock of the advances in the development of solid propellants technology in the country, to share the experiences of various agencies working in this area, and to assess the country's needs for the coming years.

It is common knowledge that the history of solid propellant rocket dates back to the twelfth

Application of resin liner to a rocket chamber





Vacuum casting of solid propellants at SPROB

A solid rocket motor case Insulation getting ready for curing in the autoclave

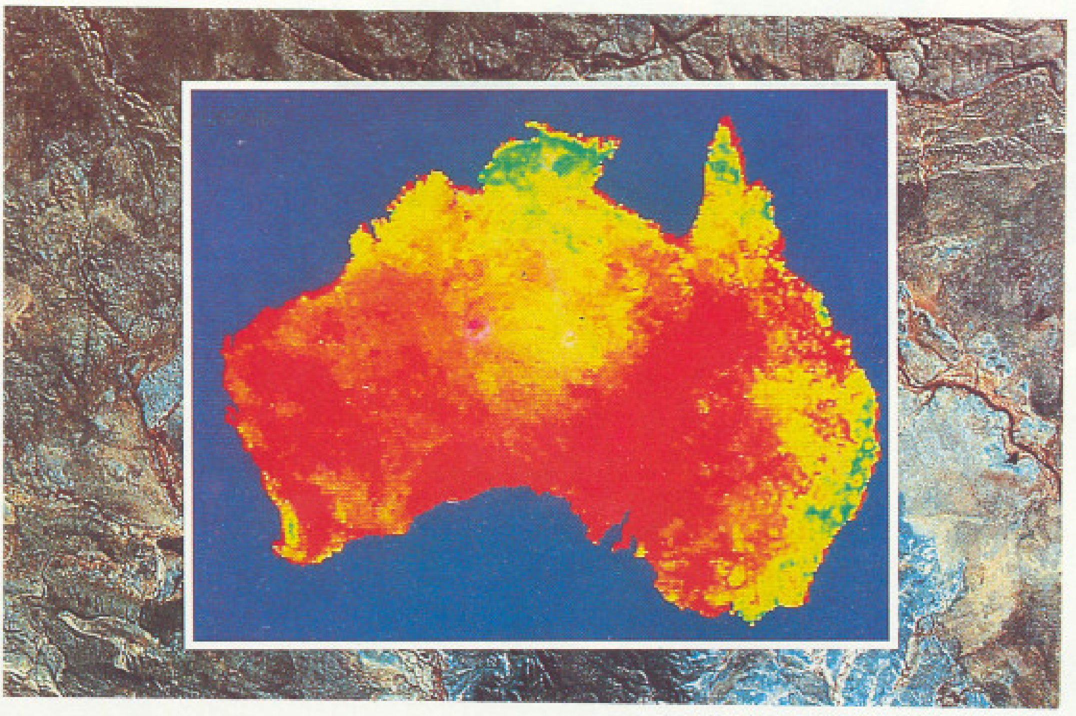
century Chinese 'Arrow of Flying Fire'. Though efforts in our country in this technology can be traced to the famous Mysore war of later years, it is only in the last 25 years or so that systematic research, development and production have been carried out. This is particularly so in the case of rocket applications. We have progressed in this period from developing small propellant grains to large booster motors to power space launch vehicles.

It was in the fitness of things that a symposium on this technology be held at SHAR Centre, for it is here that the country's largest solid propellant space booster plant, SPROB, is located. Over 50 papers were presented at this symposium spread over six technical sessions. Themes such as propulsion systems, combustion, igniters & pyrotechnics, materials and their formulation, testing and characterisation were dealt with in these sessions. Special attention was devoted to manufacturing techniques, hazards prevention and safety measures□

Co-operation with Australia

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia is responsible for developing and maintaining a co-ordinated space research programme comprising a series of selected projects. The CSIRO space programme, which involves some 15 research divisions and spans most scientific disciplines, emphasises remote sensing and satellite-based communication systems. The organisation has made innovative contributions to the development of reception and processing facilities. These technologies are of special relevance to a sparsely populated, resource-rich, island continent.

The Indian Space Research Organisation (ISRO) and CSIRO signed a Memorandum of Understanding in May 1987 covering co-operation in space research and applications. The MOU provides a framework for furthering Indo-Australian cooperation in the peaceful uses of outer space□



October 4, 1987 marks the 30th anniversary of the launch of Sputnik I, the Earth's first artificial satellite, by the USSR. Commemorating this historical event we reproduce below a message received from Mr. Rajiv Gandhi, Prime Minister of India. The launch of India's own first satellite Aryabhata in 1975 and the imminent launch of India's Remote Sensing Satellite IRS-1A are just two examples of the evergrowing collaboration in space between India and the USSR.

सत्यमेव जयते

PRIME MINISTER

MESSAGE

The launching of the first Sputnik by USSR on October 4, 1957 was undoubtedly the most significant scientific and technological event of the century which ushered the entire world into the new space age. The developments in the last thirty years have clearly established that the practical benefits from space, particularly in the areas of Communication, Meteorology and Remote Sensing of earth resources, can rapidly transform the human society as a whole. For the first time space has also brought in a new perspective of the oneness of human kind by shrinking both distance and time.

On the historic occasion on October 4, 1987 when USSR and the world will be celebrating the 30th anniversary of the launching of the first Sputnik, we send our very best wishes and congratulations. We are confident that USSR will continue its contribution to the development of space technology and strive to ensure that the benefits from space will spread to the entire human kind. We also hope that the extensive and very fruitful interaction between India and USSR will continue to grow to the mutual benefit of both of our countries.

New Delhi
October 4, 1987

A view of the S-Band Telemetry and Telecommand (TTC) Ground Station at Bangalore. Located along with the IRS Spacecraft Control Centre (SCC), this ground station will be one of the TTC network stations to be used for the mission operations of the Indian Remote Sensing Satellite.