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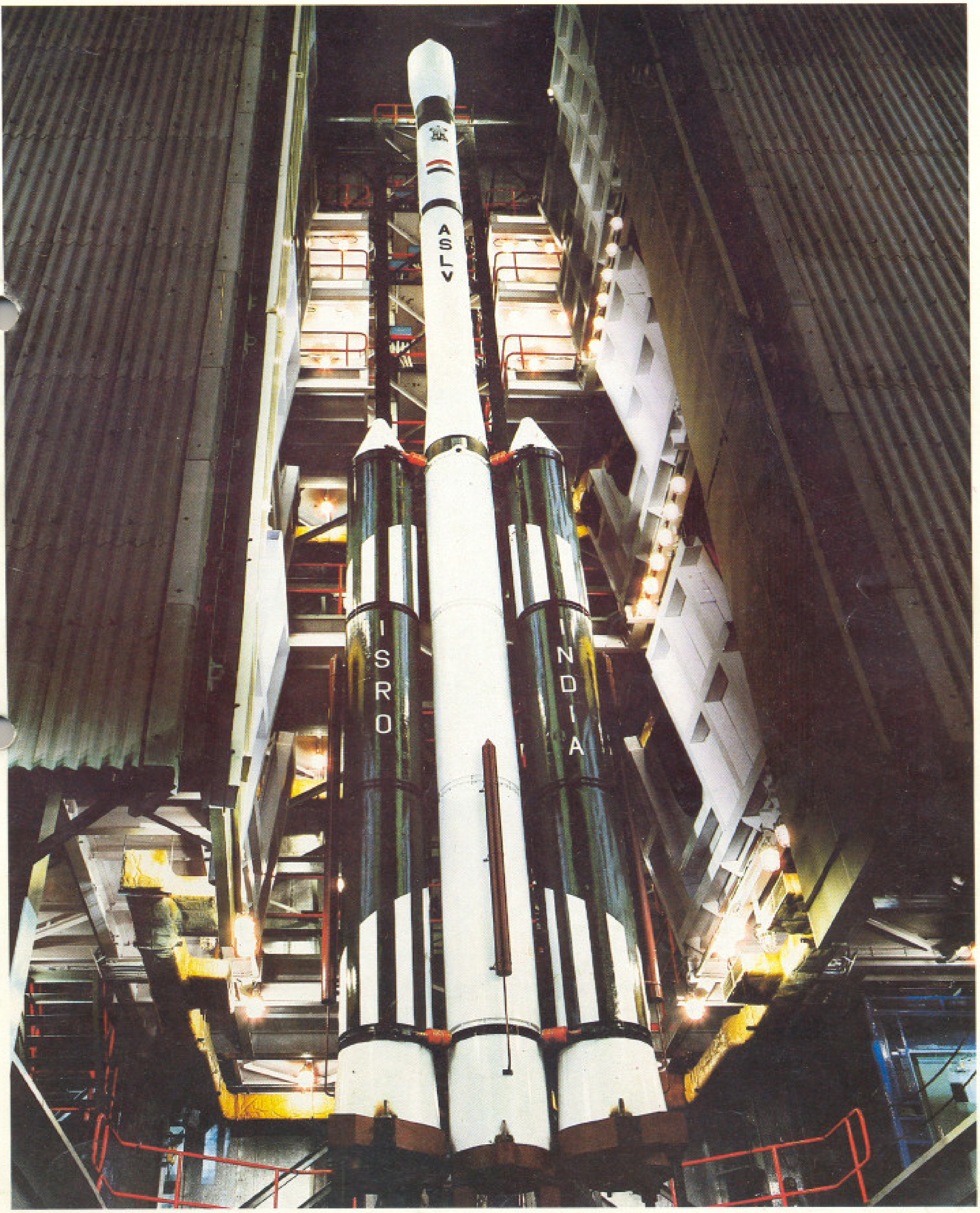
SPACE india



INDIAN SPACE RESEARCH ORGANISATION

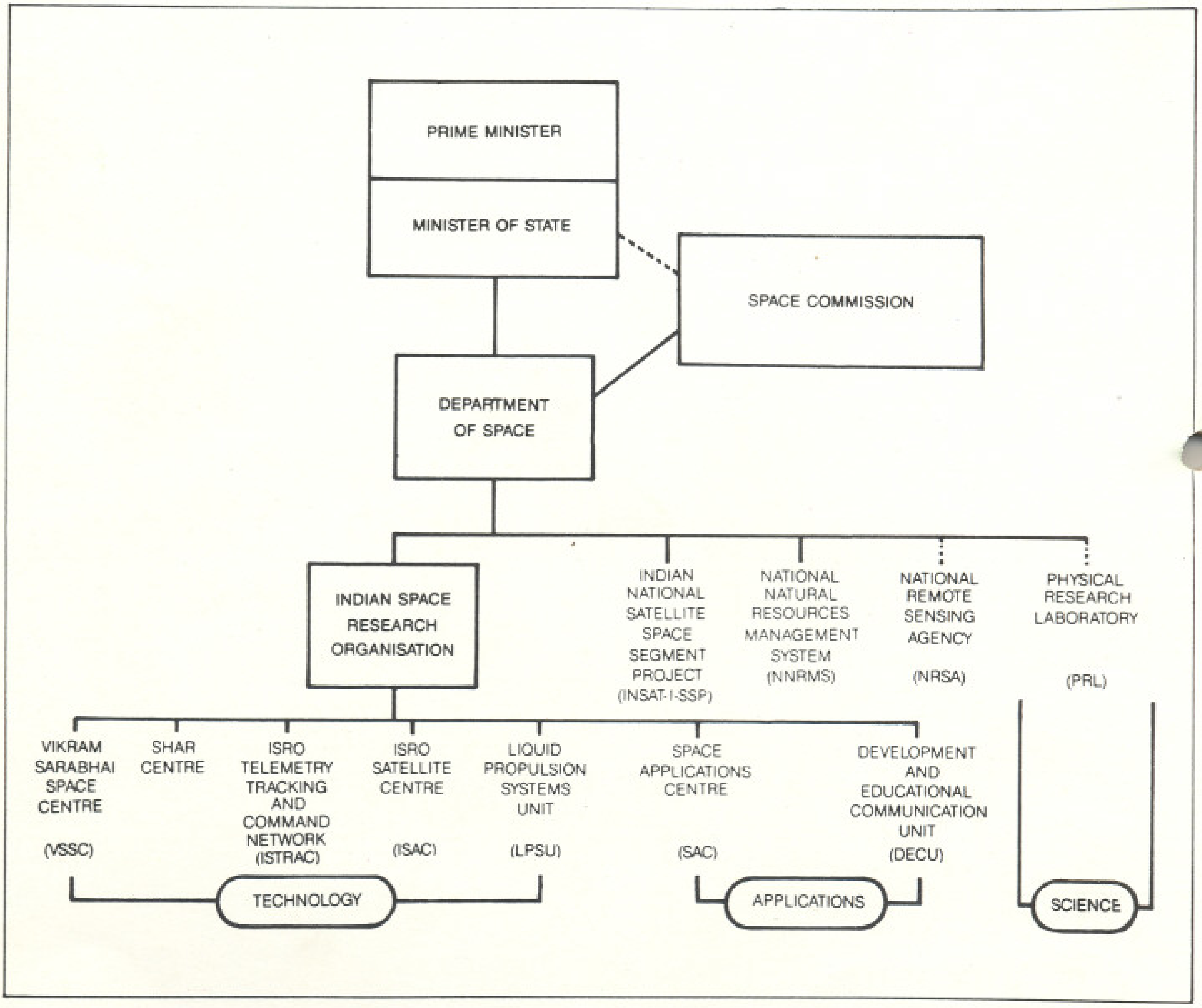
THE INDIAN SPACE PROGRAMME

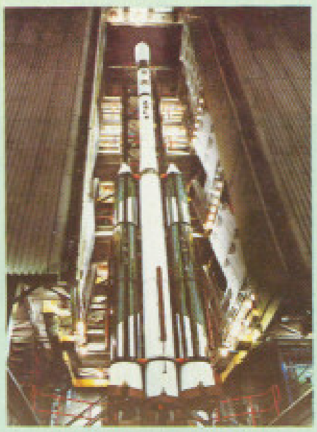
The setting up of the Thumba Equatorial Rocket Launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science 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
Full-Scale model of ASLV inside the Mobile Service Structure

EDITORS
J. Raja
S.K. Dutta

EDITORIAL ADVICE
Y.S. Rajan
Manoranjan Rao

LAYOUT & DESIGN
U. Dilip Kumar

Contents

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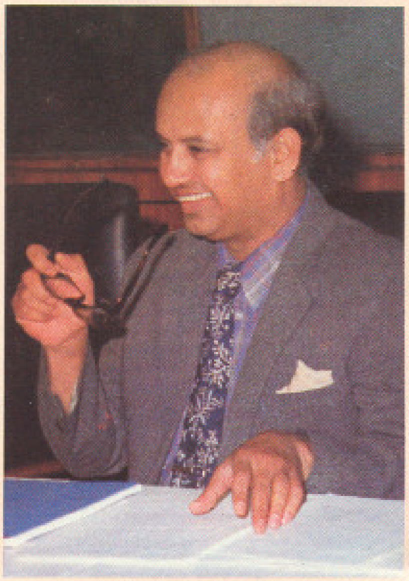
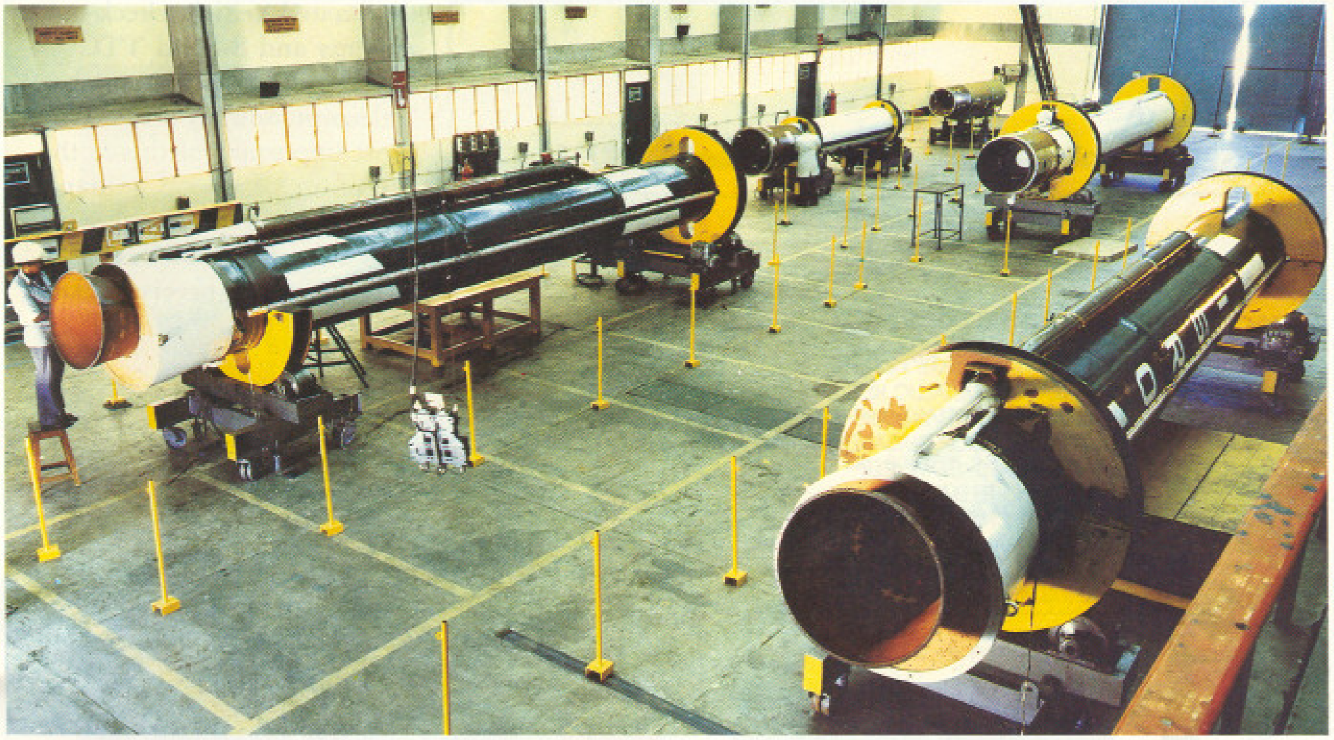
A Letter from Prof. Rao



The Indian Space Programme, from its modest beginning in 1963, has made rapid strides towards fulfilling the objectives of establishing operational space systems for national development. The benefits of a quarter century of the national space effort have already started reaching the nation's grass roots and influencing the lives of the people, thus making significant contributions to the mainstream of Indian life.

The Indian Space Research Organisation (ISRO), under the Government of India, Department of Space, has an obligation to bring the results of the Organisation's development activities to the notice of the professionals in the country and the general public. *SPACE India* is ISRO's quarterly magazine that attempts to fulfill this obligation carrying information on the activities, programmes and progress of ISRO. In fact, it is a continuation of the erstwhile newsletter, *SPACE,* which was discontinued for some time due to various reasons. I trust the readers would get a good idea of the progress the country is making in the field of space research and technology through this publication.

U.R. Rao
Chairman
Indian Space Research Organisation



ASLV stage motors ready for integration and flight

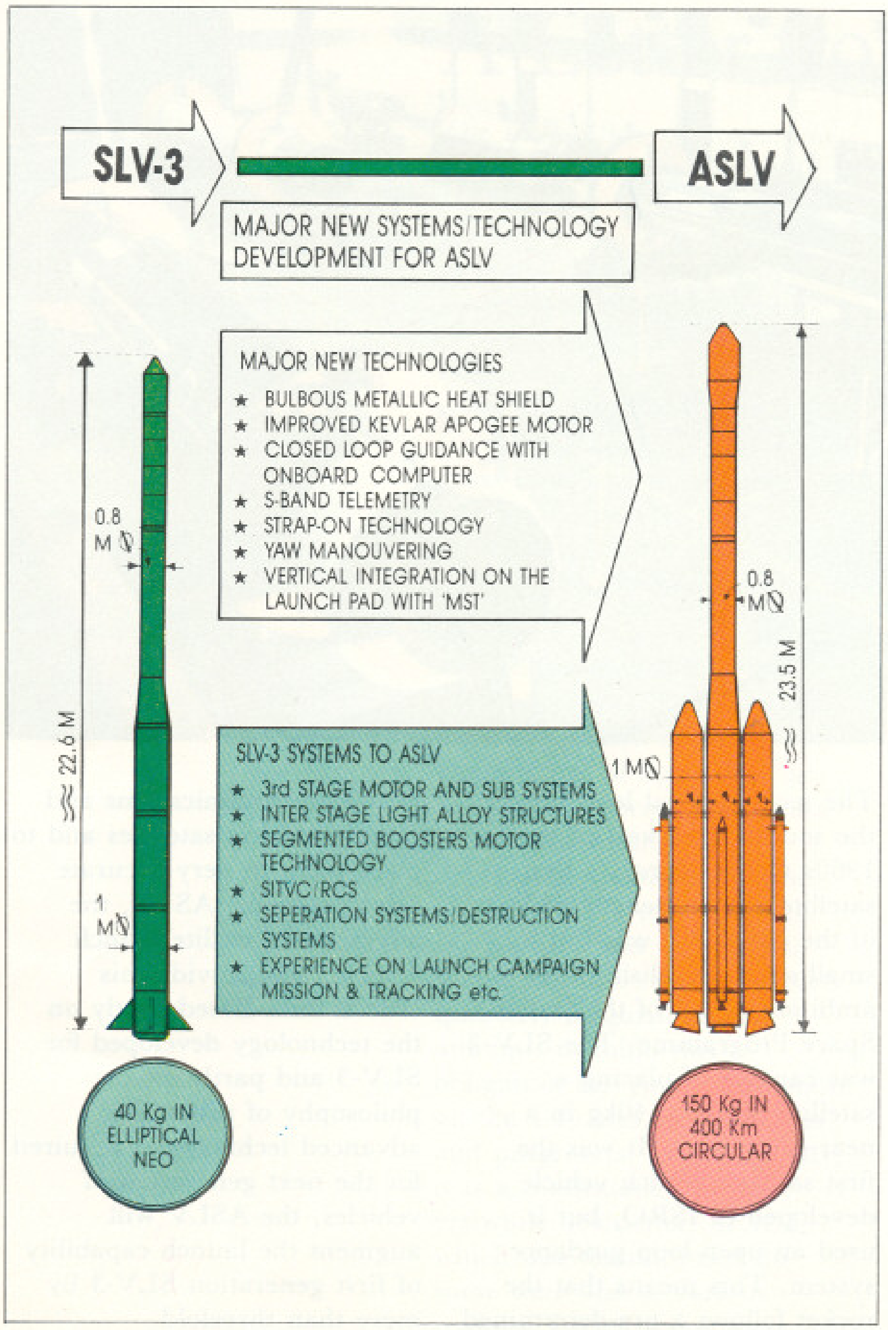
ASLV
Getting Ready for Lift-Off

The technological leap from the sounding rockets of the 1960s to the country's first satellite launch vehicle SLV-3 of the early '80s was but a small step in realising the ambitious goals of the Indian Space Programme. The SLV-3 was capable of placing a satellite of about 40kg in a near-earth orbit. It was the first satellite launch vehicle developed in ISRO, but it used an open-loop guidance system. This means that the rocket follows a pre-determined flight path which cannot be changed during flight – only corrected within certain bounds by the guidance system. The result of this is lesser accuracy in achieving the final orbit. All the same, SLV-3 was a significant step towards indigenous development of launcher capability.

The next step is indeed a more important one. For, this will be the only intermediate step before reaching the goal of achieving indigenous operational launcher capability, namely the ability to launch heavier communications and remote sensing satellites and to place them in very accurate orbit positions. ASLV, the augmented satellite launch vehicle, will provide this crucial link. Based partly on the technology developed for SLV-3 and partly on the philosophy of providing advanced technologies required for the next generation of vehicles, the ASLV will augment the launch capability of first generation SLV-3 by more than threefold.

The first launch of the ASLV rocket, dubbed the ASLV-D1, will carry SROSS-1 (Stretched Rohini Series of Satellites) satellite on-board. The lift-off is scheduled to take place during the end of March this year. The exact launch date will be fixed by the Launch Authorisation Board (LAB) after a detailed review of the readiness of all systems and facilities.

Like its predecessor, the SLV-3, ASLV also uses solid propellants in the rocket



SLV-3 to ASLV: technology linkage

stages. The word 'Augmented' in its name refers to its capability to orbit larger payloads than that of SLV-3. This is made possible by strapping-on a pair of additional rocket motors to the first stage of the core vehicle. These 'strap-on' motors constitute what is known as the 'Zeroth Stage' of the vehicle. Thus ASLV will have altogether five rocket motor stages as compared to four of SLV-3.

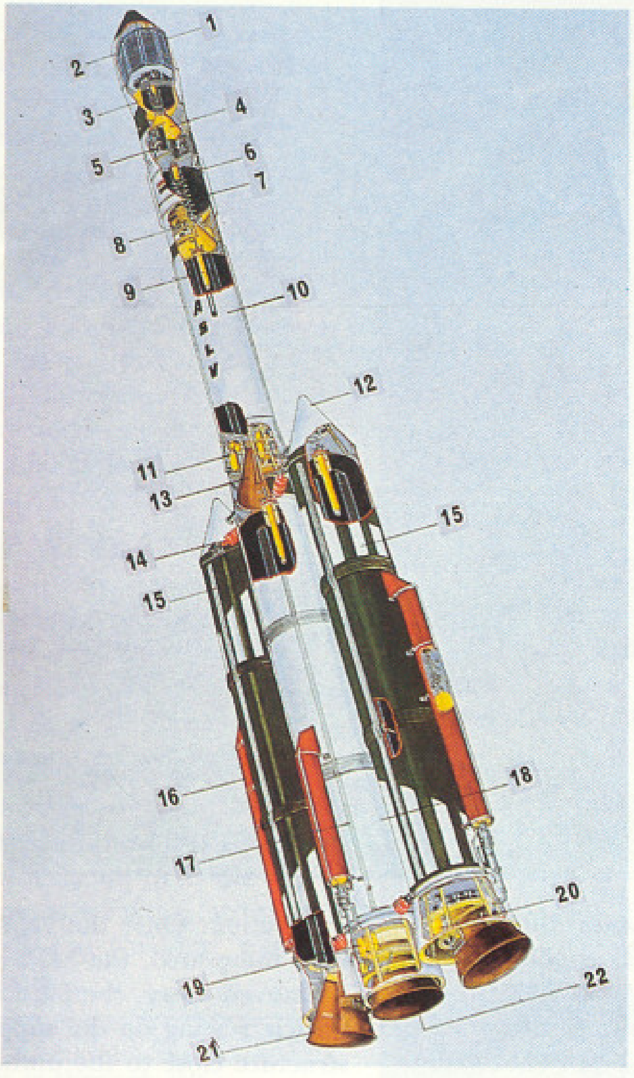
Besides augmentation of the basic payload capability ASLV employs everal new technologies which are crucial for the development of future launcher capabilities. These range from use of high energy propellants, canted nozzles, and new jettisoning mechanisms to application of state-of-the-art technologies such as closed-loop guidance systems, automated vehicle check-out systems and S-band TTC (Tracking, Telemetry and Telecommand) systems. The most important of this is the use of a closed-loop guidance scheme which will enable injection of the satellite payload into a precise circular orbit.

The SROSS Satellites:

SROSS refers to a series of satellites called the Stretched Rohini Series of Satellites which, of course, are designed taking into account the capabilities of the ASLV rockets. The satellites in the SROSS series weigh about 150kg each and would offer excellent opportunity for experiments in space sciences, space technology and applications. The basic spacecraft design is modular providing for adequate flexibility to accommodate either three-axis-stabilised or spin-stabilised payloads.

Octagonal-prismoidal in shape, the SROSS has both body-mounted and deployable solar panels around the mainframe. SROSS-1, the first of the series, will be launched by the first ASLV flight. This satellite will carry out experiments in laser tracking and celestial gamma-ray bursts besides monitoring the dynamic environment and the performance of ASLV.

As with the ASLV, the SROSS-1 also employs a host of new technologies, its most remarkable feature being its ability to provide the user with almost all facilities normally available with bigger state-of-the-art spacecraft. The major new technology areas include S-band TTC system; indigenous reaction control system, indigenous solar cells,



1. SPACECRAFT
2. HEATSHIELD
3. STAGE-4 MOTOR
4. STAGE-4 NOZZLE
5. EQUIPMENT BAY
6. STAGE-3 IGNITER
7. STAGE-3 MOTOR
8. STAGE-3 CONTROL SYSTEM
9. STAGE-2 IGNITER
10. STAGE-2 MOTOR
11. STAGE-2 CONTROL SYSTEM
12. STRAP-ON MOTOR NOSE CONE
13. STAGE-2 NOZZLE
14. STRAP-ON JETTISONING SYSTEM
15. STRAP-ON MOTORS (ZERO STAGE)
16. EXTERNAL TANK (TVC)
17. DESTRUCTION SYSTEM
18. STAGE-1 MOTOR
19. STAGE-1 CONTROL SYSTEM
20. ZERO STAGE CONTROL SYSTEM
21. CANTED NOZZLE
22. STAGE-1 NOZZLE

ASLV: cut-out view

ASLV Stage Motors & Control Systems

	Stage-0 (Two strap-ons)	Stage-1	Stage-2	Stage-3	Stage-4
Length	10m	10m	6.35m	2.25m	1.4m
Diameter	1000mm	1000mm	800mm	800mm	650mm
Propellant	Solid	Solid	Solid	Solid	Solid
Casing	High Strength Steel (15 CDV 6)	High Strength Steel (15 CDV 6)	High Strength Steel (15 CDV 6)	Fibreglass	Poly aramide
Nozzle	Canted	Straight	Straight	Straight	Contour
Weight	10,000 Kg	10,000 Kg	3,800 Kg	1225 Kg	375 Kg
Control Systems	Secondary Injection Thrust Vector Control (SITVC) & Cold Gas RCS	SITVC & Mono-propellant RCS	Bipropellant RCS	Mono-propellant RCS	Spin-stabilized

panels and chemical batteries; use of microprocessor based mainframe systems; automated spacecraft attitude and orbit control systems; and hybrid micro-packaged circuits. The second mission in the SROSS series, SROSS-2, will be a joint collaboration experiment in remote sensing between ISRO and DFVLR of West Germany. SROSS-3 is expected to carry Indian aeronomy experiments while SROSS-4 will involve an X-ray payload.

While the ASLV is being developed at the Vikram Sarabhai Space Centre (VSSC) at Trivandrum and SROSS-1 at the ISRO Satellite Centre (ISAC) at Bangalore, the actual launching will be from the SHAR Range of Sriharikota, the premier launch facility of ISRO. SHAR has already turned into a bee-hive of activity preparing for the lift-off. For the first time in the country vertical integration of launch vehicle is attempted in this mission. A gigantic Mobile Service Structure (MSS) has been erected for this purpose. The MSS is a 40 metre tall, 500t tractionable mobile steel building. It has foldable access platforms, cranes, lifts and clean rooms to enable integration of the launch vehicle. The MSS also serves as a weather-proof enclosure for the rocket during integration. Once the vehicle is fully integrated, the MSS will be moved away, the launch vehicle resting on the support structure close to the umbilical mast. Pneumatic support arms will support the vehicle until the actual lift-off.

Generic Features of SROSS

Shape and Size
Octagonal prismoidal
700 mm across flats
1100 mm height

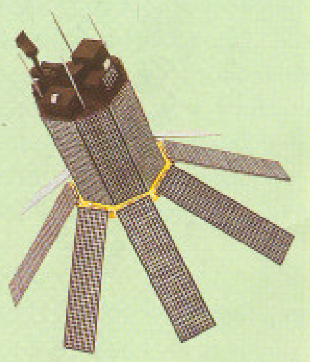
Weight
150 Kg

Power
Solar array power
90-110w Batteries
(Ni-Cd) : 12 AH

Thermal System (Temperature Limits)
Payload deck plate : 20° to 50°C
Main frame : 0-40°C

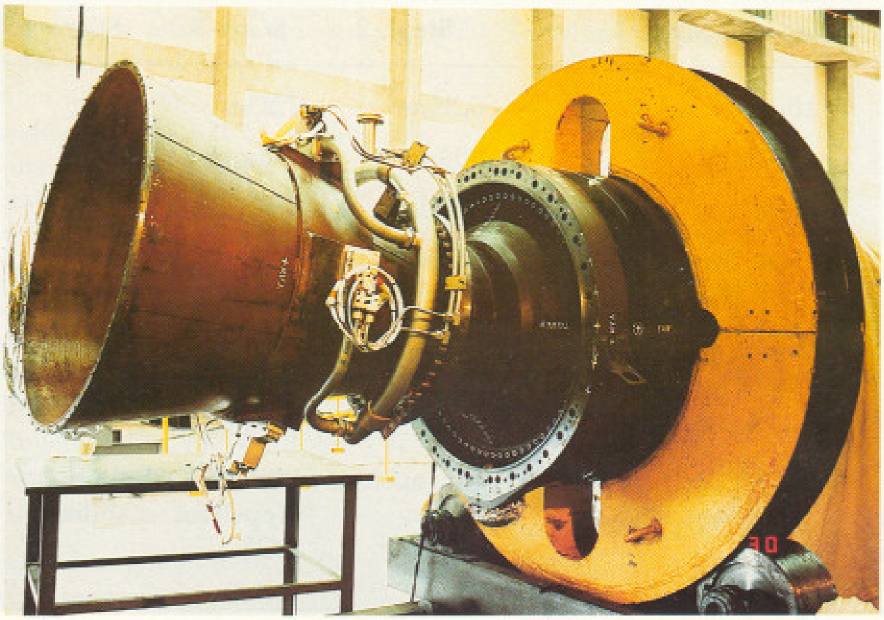
Controls (Attitude and Orbit)
Dual axis/3 axis/Spin stabilised (as demanded by Experiment)

RCS
Monopropellant (Hydrazine)



Sensors
Conical Earth Sensors
Magnetometer
Sun Sensor

TTC
Telemetry
S-Band transmission with PCM/PSK/PM
Telecommand
S-Band (128 Commands)
Tracking
S-Band and Optical (laser)



Canted nozzle of the ASLV strap-on motor

Prior to the lift-off, the launch sequence operations will be tested by a check-out system located in the Block House situated a few hundred metres away from the MSS. A distributed processing concept is used for this computerised pre-launch check-out. In addition, a real-time computer network linking radars, telemetry stations and other tracking sources will provide information on the behaviour of the rocket after lift-off. Such real-time information ensures range safety measures.

Once the rocket leaves the launch pad, the only contact

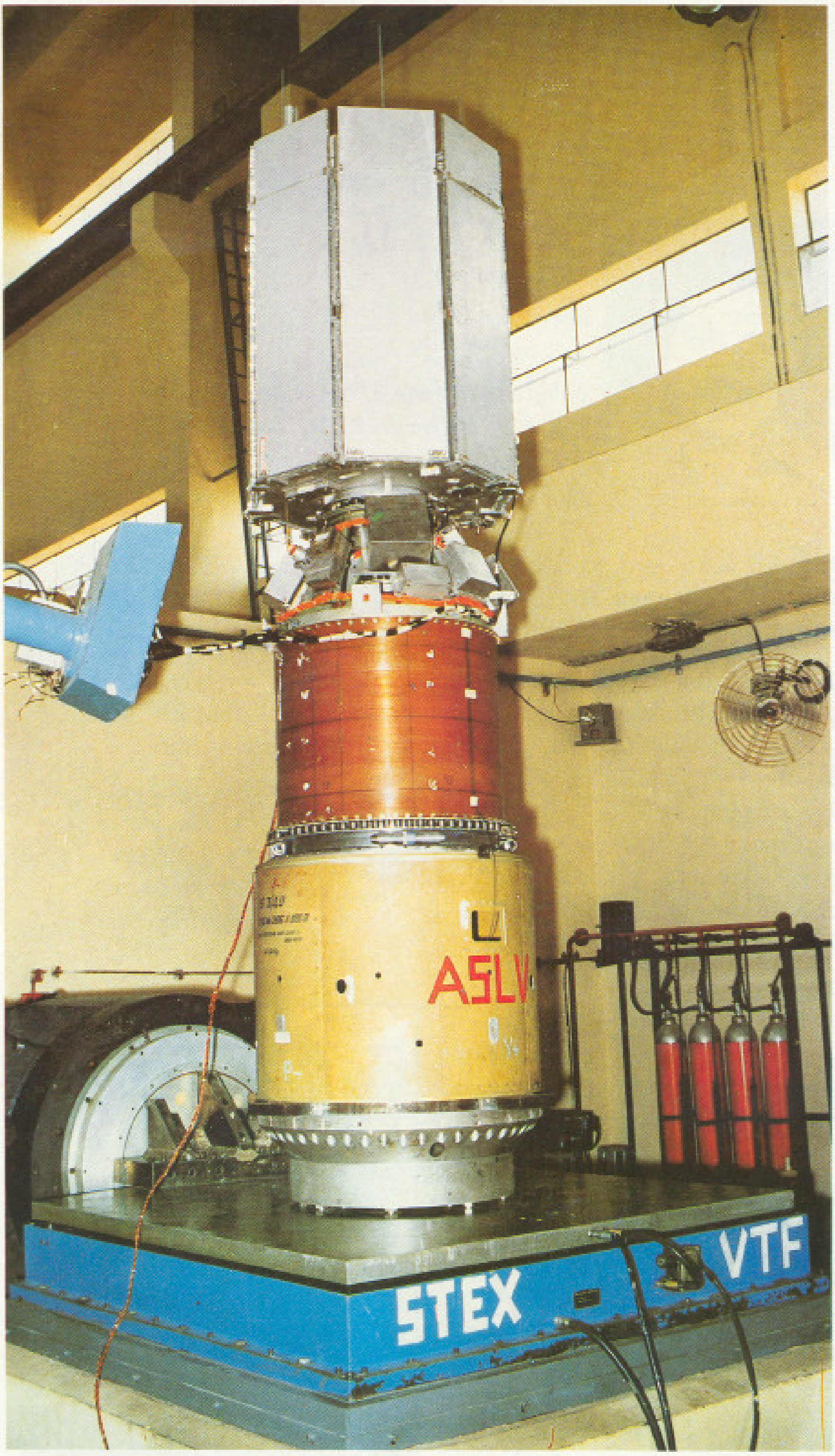
Payloads of SROSS-1

(1) VIDE: Velocity increment Determination Experiment is the launch vehicle monitoring payload to evaluate the performance of the fourth stage of the ASLV.

(2) SAVE: Shock, Acoustics and Vibration Experiment is the payload aimed at validating the environmental levels that a satellite would be experiencing onboard ASLV.

(3) GRBE: The Gamma-Ray Burst Experiment is a Scientific payload to measure celestial gamma-ray bursts in the energy range of 20 Kev - 3 Mev.

(4) A laser tracking experiment package consisting of retro reflectors to optically track the satellite from the optical tracking facility of ISRO at Kavalur, Tamil Nadu.



Stack test of ASLV upper stage with SROSS model on vibration table

with it is through the Telemetry, Tracking and Command (TTC) network. The ISRO Telemetry Tracking and Command Network (ISTRAC) has established full-fledged S-band TTC stations at SHAR, Trivandrum and Car Nicobar. In addition tracking support will also be obtained from stations located at Carnarvon, Australia and Weilheim, West Germany during certain crucial phases of the launch.

In contrast to the earlier experimental and developmental missions of SLV-3, the ASLV-SROSS missions aim at operationalising indigenous launch vehicle technology. The ultimate goal identified for ISRO is to establish indigenous operational systems both for remote sensing and communications applications. Towards this goal, the ASLV-SROSS missions will mark a significant milestone□

An Interview with M.S.R. Dev

Sometime in early 1986, **Countdown,** *the house journal of the Vikram Sarabhai Space Centre at Trivandrum, interviewed Mr. M.S.R. Dev, Project Director, ASLV and Mission Director, ASLV-D1/SROSS-1 mission. With the permission of* **Countdown,** *we publish an extract from this interview.*

Q: *What is the main objective of the ASLV Programme and what is the mission for the first launch?*

A: The major objective of the ASLV Pogramme is to realise a launch vehicle capable of placing a 150 kg satellite into a nominal 400 km orbit, thereby increasing the country's present launch capability more than three fold for Low Earth Orbit missions.

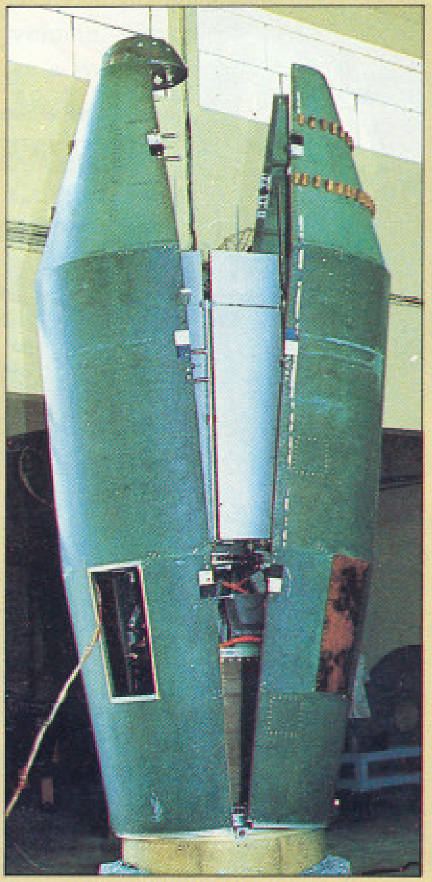
The main task of the Programme, therefore, is to develop and qualify a number of indigenous technologies and subsystems relevant not only to the ASLV, but also to future launch vehicles of ISRO. Once developed and qualified, ASLV will be the workhorse of ISRO for Low Earth Orbit missions in the fields of space technology, space science and space applications.

The first ASLV is a technological mission which seeks to (i) establish the vehicle characteristics and (ii) evaluate performance of main spacecraft systems. Besides, the satellite (SROSS) will also carry certain scientific experiments.

Q: *What are the new technologies developed for ASLV?*

A: The major new technologies developed and being experimented with in ASLV are

- Closed loop guidance system with stabilised inertial platform and onboard computers.
- Strap-on technology which includes strap-on rocket motors with canted nozzles, and strap-on jettisoning system.
- S-band Range and Range-rate Transponder—SRRT (to aid tracking during injection of satellite).
- Spin up bearing system (to reduce disturbance during separation of the fourth stage).
- Bulbous metallic heatshield with pyro-mechanical jettisoning system.
- High flow regulators and valves for control systems.
- Autonomous controls using SITVC system and high thrust mono-propellant thrusters (50 kg) and cold gas roll control system.
- Mobile service structure and launch facilities for vertical assembly and launch operations.
- S-band ground stations for telemetry, tracking and command network.
- Microprocessor-based checkout systems with distributed processing concept.



Heat-shield separation test

- A host of software modules (for trajectory dynamics, navigation, guidance, digital autopilot, preliminary orbit determination, lift-off dynamics, separation dynamics, orbital analysis, ground simulation and hardware-in-loop simulation tests, systems checkout and launch vehicle checkout).

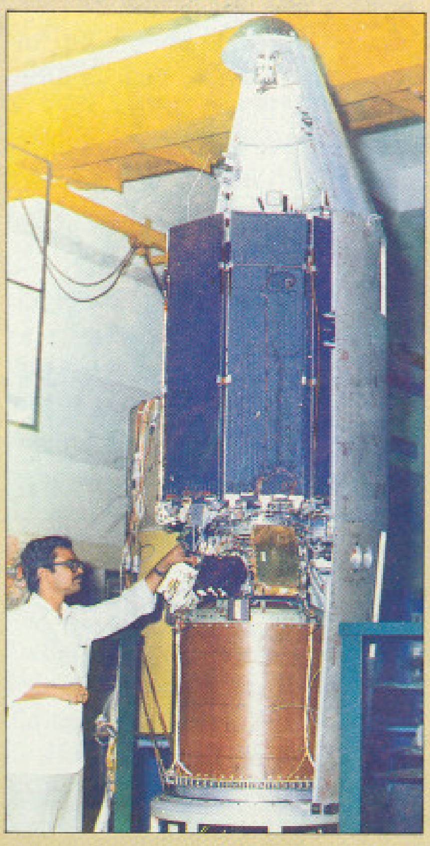
Q: *What are the new facilities established for the development of ASLV? Please give us some details.*

A: The mechanical integration facilities established during the SLV-3 Programme have been augmented to handle different sub-assemblies of ASLV. A new facility for integration and checkout of the electrical sub-assemblies of ASLV under controlled environment has been established. New test fixtures and facilities have been added for conducting full scale strap-on jettisoning tests. Test fixtures for conducting integrated structural testing of ASLV strap-on systems have also been fabricated. In-house facilities have been augmented to enable fabrication of heatshield and interstage structures. Test facilities have been commissioned for carrying out hybrid simulation and hardware-in-loop simulation for inertial guidance system. Launch pad facilities including vertical assembly and mobile service tower, umbilical mast, launch pad services etc. have been established in SHAR near the erstwhile SLV-3 launch pad. All the facilities and services needed for the vertical integration of ASLV have been fully taken care of. Launch vehicle checkout systems and associated launch operation consoles are also being commissioned in the Block House at SHAR.

Q: *What is the rationale for vertical integration?*

A: Satellite launch vehicles are launched vertically, which means you have to keep the vehicle in a vertical position at the launch pad. You can do this in either of two ways: you can, for example, integrate the stages and the vehicle horizontally in a separate building (e.g. vehicle assembly building), transport it in a suitable transporter to the launch pad, mate it with the launch tower in a horizontal position and then finally elevate the tower to vertical position before the launch. You may recall that this was exactly the procedure we had followed for launching the SLV-3. Or else, you can integrate the whole vehicle vertically at the launch pad, for which you need to establish new facilities like the Service Structure. The latter procedure has several advantages when the vehicle is big and massive, especially when it has strap-ons. Also since the transportation of the fully integrated vehicle is involved, the vertical assembly results in reduction of loads induced on the vehicle during handling procedures. It is also relatively easier to align and

Block-house



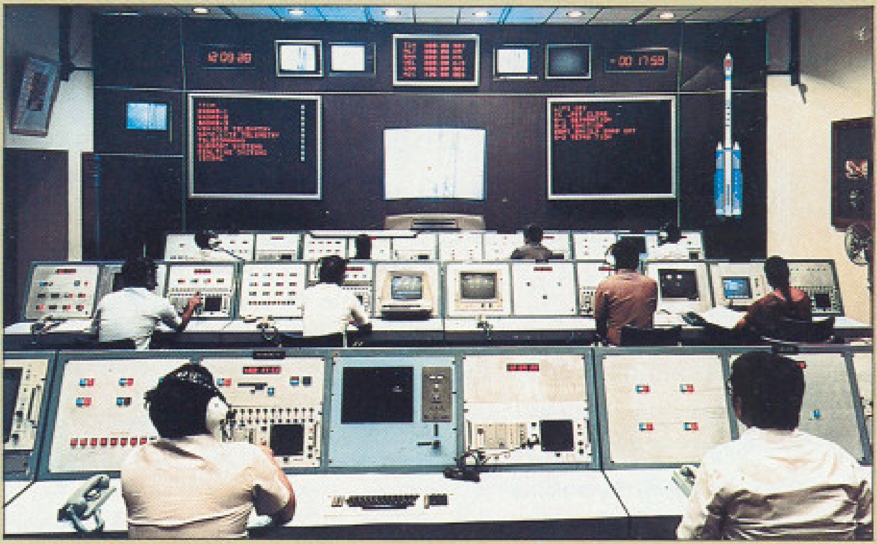
Launch vehicle and satellite undergoing compatibility test assemble individual stages vertically. Finally, the experience we gain from vertically assembling the ASLV will be of immense value to our future launch vehicle programmes like the PSLV and GSLV.

Q: *In all ISRO projects there has always been a certain emphasis on involving the Indian industries. What is the situation like, in the ASLV Project?*

A: In line with the ISRO philosophy, ASLV Project has maximally utilised the Indian industries, both in the public and private sectors; we have also exploited the small scale industries in every possible way. You probably may not be interested to know the complete directory of industries involved in the Project. But let me inform the readers of *Countdown* that the total number of industries contributing significantly to the Project is around 80. While on this subject, let me add that whenever we had a problem (of technology or schedule) with any outside agency, we turned to our in-house facilities, which have done a really good job.

Q: *Have any academic institutions been involved in the Project? If so, please identify their roles.*

A: Academic institutions such as the Indian Institute of Science and Indian Institute of Technologies were involved in different phases of the Project. IIT, Kanpur, for example, has developed a separate software module for preliminary orbit determination. The professionals from various academic institutions have played key roles as members of the PDR and CDR teams and in reviewing and analysing the wind tunnel test programmes, aeroelastic testing/analysis etc.



Launch Control Centre

Q: *Obviously you have gone through very trying circumstances in managing the Project. What were your most frustrating moments and what were the most gratifying ones?*

A: When you are in charge of a project you just can't afford to be frustrated. Surely, we have gone through many trying circumstances and indeed, we continue to do so. Failures are certainly disappointing and there were quite a few in the initial phases of development. But in the final analysis, such failures have only increased our investigative skills. Moments of elation and of disappointment are all parts of the game called 'Project'. With experience one learns to play it cool!

Q: *How do the technologies developed for ASLV feed into PSLV project?*

A: The major technologies that feed directly into the PSLV are

- Closed loop guidance system with on-board computers
- Software packages for navigation, guidance, control, trajectory dynamics, orbital analysis, separation dynamics etc.
- S-band telemetry system
- Strap-on motors with canted nozzles.
- Kevlar material processing
- Metallic heatshield fabrications
- Vertical assembly, integration and related operational procedures.

Q: *Besides ISRO, are there any prospective users for ASLV?*

A: The second ASLV launch is likely to carry the payload called MEOSS (Monocular Electro Optical Stereo Scanner) which is essentially a remote sensing payload being developed by DFVLR, West Germany. There are also some preliminary enquiries from U.K. regarding the availability of ASLV. We in ISRO are yet to evolve a long term policy for exploiting the commercial potential of our launch vehicles□

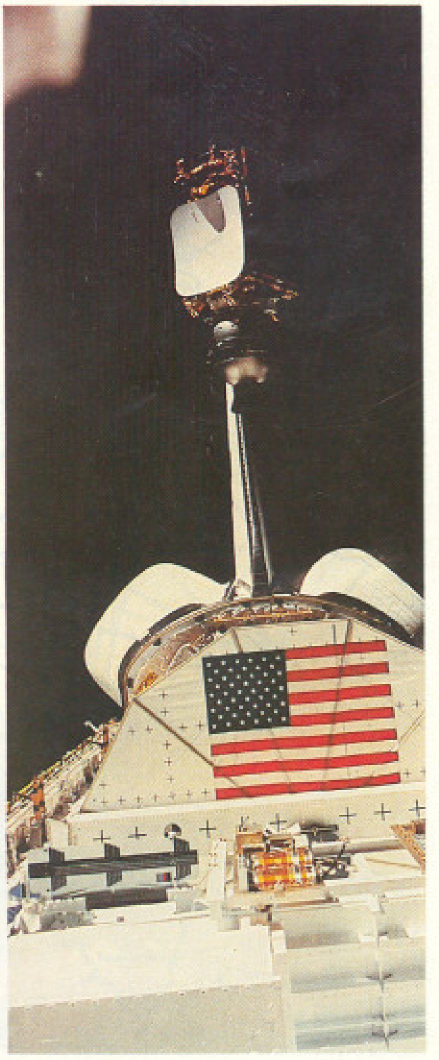
INSAT-IB

Three years in orbit

The first generation Indian National Satellite System (INSAT-I) represents India's first step towards implementing 'operational' space systems for identified national requirements. It has been designed specifically for India's requirements, with sub-systems and elements largely based on proven technology and experience. Built by the Ford Aerospace & Communications Corporation (FACC), USA the INSAT-I is a multi-purpose domestic satellite system providing for various national applications. Among these are

- long distance communications
- meteorological earth observation
- nationwide TV broad-casting and programme distribution
- nationwide radio programme distribution

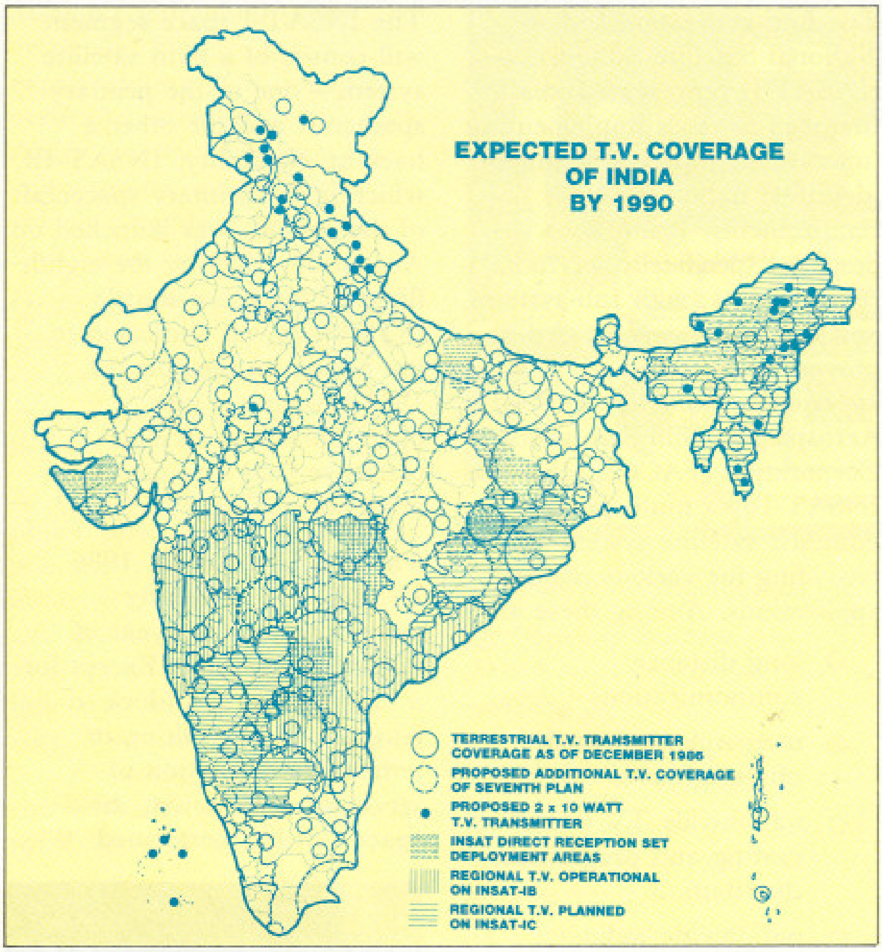
The unique multi-purpose nature of the system is reflected not only in the design of the spacecraft but also in multiple use of several key ground facilities, resulting in significant economies. The INSAT system is a joint venture of the Department of Space (DOS), the Department of Telecommunications (DOT), the India Meteorological Department (IMD), All India Radio (AIR) and Doordarshan — thus cutting across the traditional boundaries of government departments and agencies.

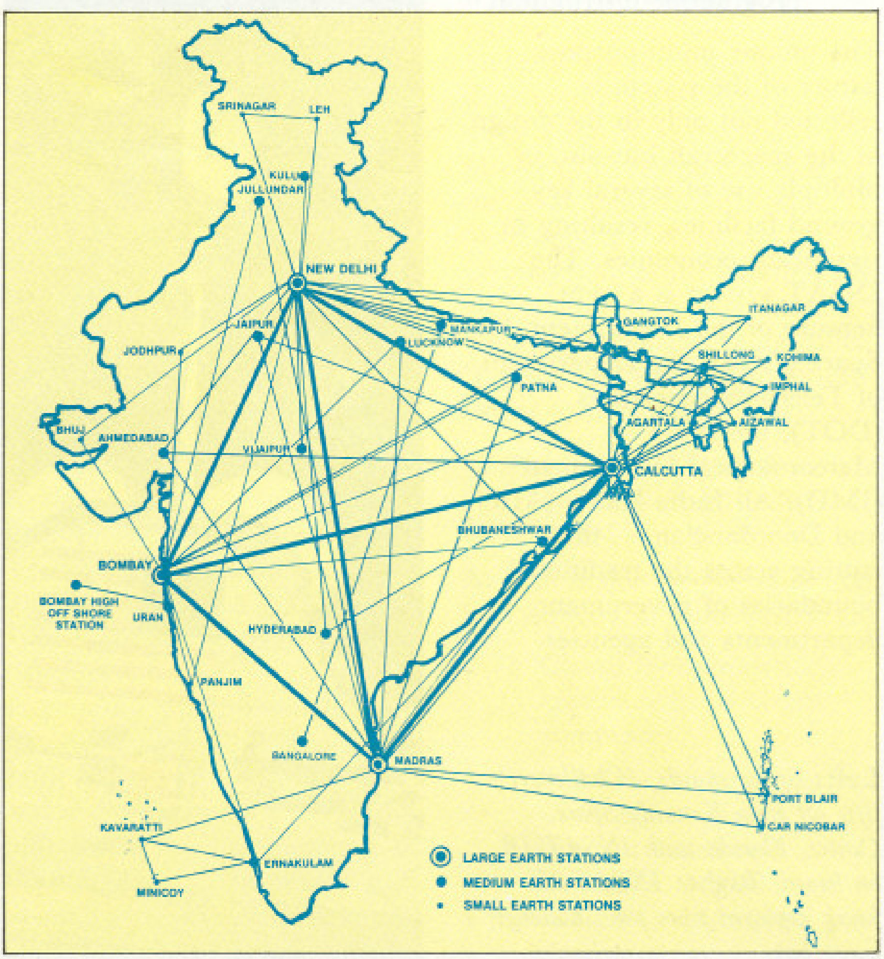


Left: *Space shuttle, 'Challenger', lifts off from Kennedy Space Centre, Florida with INSAT-IB on board.* **Right:** *INSAT-IB being deployed from the Challenger's cargo bay.*

The INSAT-I space segment will consist of a twin satellite system – one as the primary spacecraft and the other a back-up capability. INSAT-IB, which is the primary spacecraft of the system, was launched on August 30, 1983 by the eighth flight of the space shuttle (STS-8). It was dedicated to the nation on October 15, 1983 bringing it into operational service after extensive tests and precise orbit positioning.

Thus on October 15, 1986 INSAT-IB successfully completed its third year of operational service. Except for a brief loss of earth-lock in August 1984, resulting in temporary disruption of services for 36 hours, the spacecraft has performed





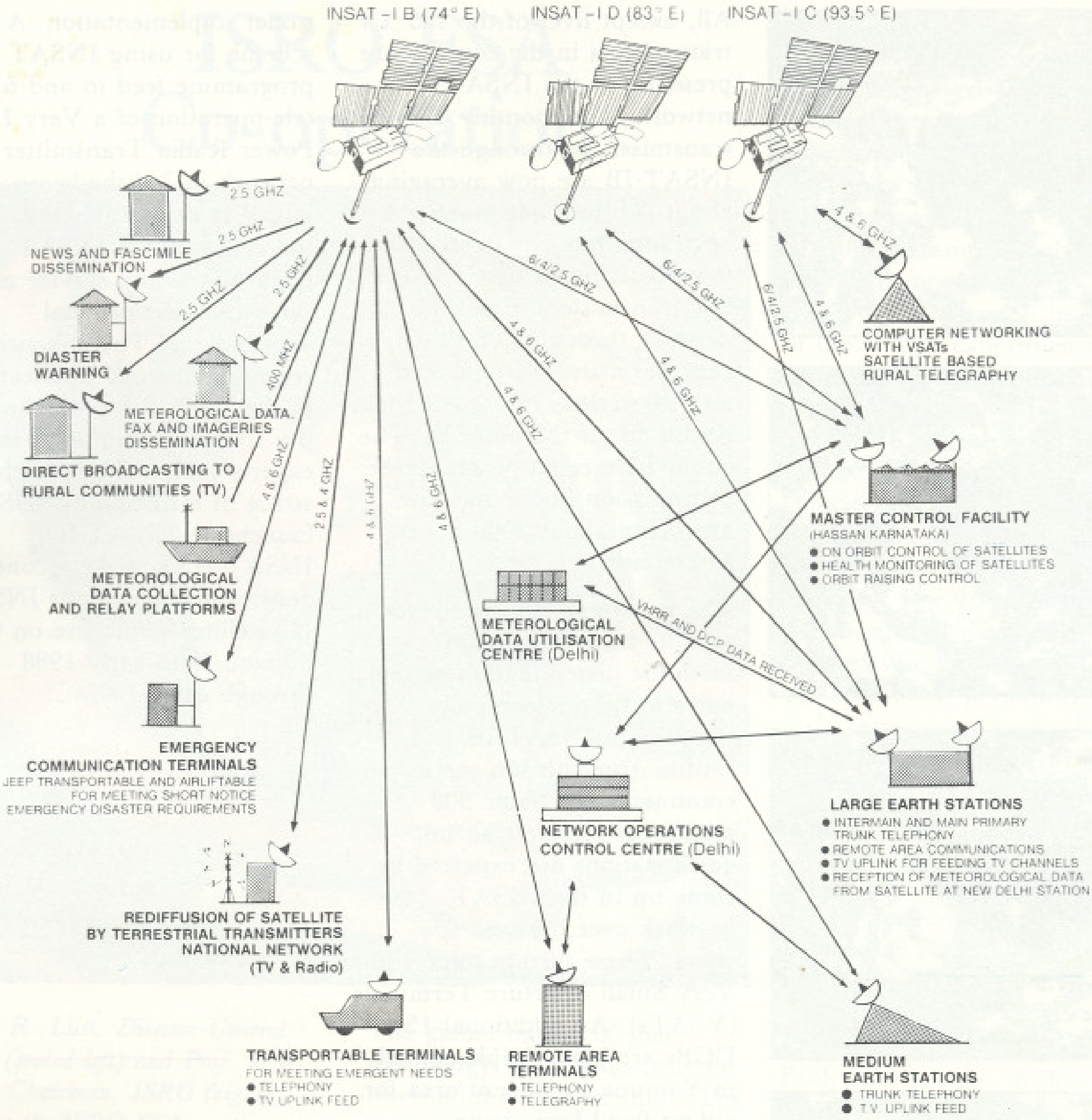
satisfactorily throughout. All four service payloads onboard are being routinely utilised by the user agencies.

Utilisation

Presently 38 telecommunication earth stations are in operation in the INSAT-IB network. They provide 3961 two-way voice or equivalent circuits to 69 telecommunication routes. More than 13500 meteorological images have been provided by the Very High Resolution Radiometer (VHRR) on board the spacecraft. INSAT's VHRR is a meteorological imaging instrument which has joined the very small and select group of geo-stationary VHRR instruments that have completed three years of continuous operation without any failures. The relay transponder onboard INSAT-IB is used for collection of meteorological, hydrological and oceanographic data from remote uninhabited locations. One hundred Data Collection Platforms (DCPs) have been deployed at such locations around the country, including one at the Indian Base Station at Antartica. Another transponder on-board relays warning messages from the Area Warning Centre at Madras, to 100 Disaster Warning System (DWS) receivers in selected cyclone-prone coastal areas of Andhra Pradesh and Tamil Nadu.

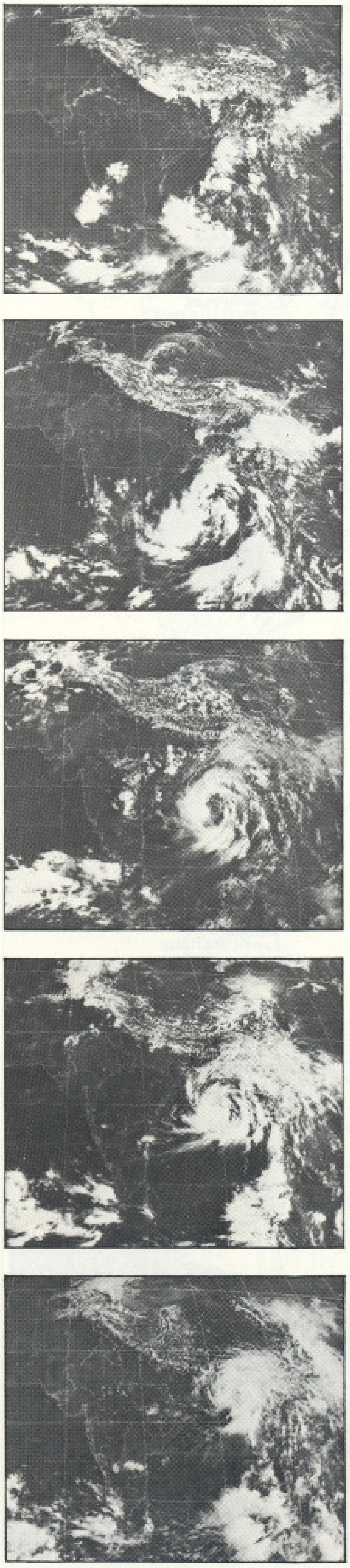
Expected TV coverage of India by 1990

INSAT-I telecommunications trunk routes as of December 1986



INSAT-I system concept

Master Control Facility (MCF) at Hassan, Karnataka. The new 7.5 metre antenna for INSAT-IC is seen in the foreground.



All, except five, of the 185 TV transmitters in the country are presently in the INSAT network. The monthly TV transmissions, through the INSAT-IB are now averaging about 800 hrs. per month. A beginning has also been made towards regional networking of TV transmitters. One radio network through INSAT-IB provides a five channel feed and 94 stations of the All India Radio are in the network. The cumulative radio programme transmission hours are now averaging about 2000 hours per month.

The prototype equipment for a satellite based news and facsimile dissemination system has also been successfully tested with INSAT-IB and routine transmission service commissioned. Some 300 additional receive/transmit earth stations are expected to come up in the INSAT network over the next few years. These incude some 130 Very Small Aperture Terminals (VSATs). An additional 15 DCPs are being implemented in Yamuna catchment area for aiding flood forecasting. Deployment of additional 35 DCPs and 100 DWS receivers is also being considered by IMD. Use of INSAT for national service radio channel has been approved and is under implementation. A scheme for using INSAT for programme feed to and for tele-operation of a Very Low Power Radio Transmitter network in Lakshadweep Island is also in making. Thus the demands for INSAT applications and service now far exceed the original expectations. The enhanced requirements and applications of the INSAT services have led the INSAT community to eagerly look forward to the string of forthcoming INSAT launches - INSAT-IC, INSAT-ID and the second generation indigenous INSAT-II satellites - that are on the horizon from early 1988 through early 1990s□

INSAT-IB satellite images taken of a cyclone 21-25 May, 1985.

ISRO-ESA Co-operation

Prof. R. Lust, Director-General, ESA (seated left) and Prof. U.R. Rao, Chairman, ISRO (right) during the ISRO-ESA meeting.

The global nature of space technology has always fostered international co-operation. The very origins of Indian Space Research Organisation (ISRO) are traceable to the establishment of the Thumba Equatorial Rocket Launching Station (TERLS) which was dedicated to the United Nations way back in 1968.

Specifically, the co-operation between India and Europe dates back to 1971 when the first Memorandum of Understanding (MOU) was signed between the erstwhile European Space Research Organisation and the ISRO. Ties between the two organisations grew over the years and, after the European Space Agency (ESA) was formed, a second MOU was signed between them in 1977. A typical example of the fruitful co-operation between the two is the launch in 1981 of the Indian experimental communications satellite, APPLE (Ariane Passenger Payload Experiment) by Ariane, the prestigeous launch vehicle developed by ESA. The ISRO-ESA agreement was renewed in 1983 to cover a period of five years. Since then the co-operative programmes between the two agencies have been reviewed periodically by their respective Chiefs. The latest meeting between the ESA and ISRO teams, led respectively by Prof. R. Lust, Director General of ESA and Prof. U.R. Rao, Chairman, ISRO, was held during November 26-27, 1986 in Bangalore. Immediately after the meeting *SPACE India* interviewed Prof. Lust and Prof. Rao jointly; in this interview, they answer questions covering a wide range of subjects from the Manned Space Programme of ESA to the joint co-operative ventures between ESA and ISRO in Space Sciences.

Following are some excerpts from the interview.

Interview

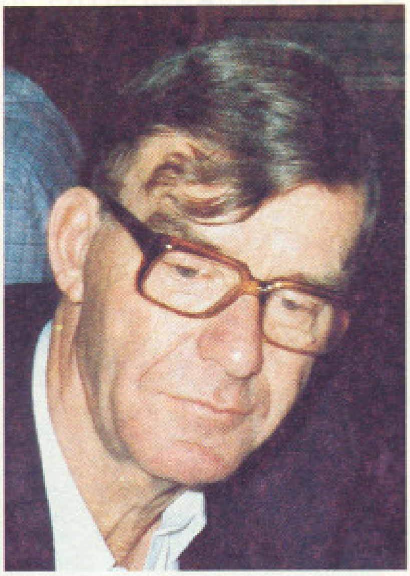
Q: *Prof. Lust, you have been here for the last two days and have had discussions with Chairman, ISRO and some of his colleagues. Could you briefly tell us what transpired in these discussions?*

Prof. Lust: We discussed the close co-operation between ISRO and ESA during these two days. Mainly we reviewed what had been achieved since the time of the last meeting. We also looked forward, at the new projects and for enlarging this co-operation.

Q: *You have been at the helm of affairs of ESA for the last couple of years. Could you highlight the achievements of ESA in these two years?*

Prof. Lust: One of the special highlights was the GIOTTO mission to Comet Halley. Although I cannot take any credit for the success of this mission, this was also a particular highlight for me personally since my own scientific work is related, in certain parts, to cometary work and to the exploration of the Solar System.

Prof. Rao: Prof. Lust is very modest. In fact, the first time the concept of solar wind came into being was from the work of Prof. Byerman and Prof. Lust long back, when they looked at the acceleration of cometary tails. Prof. Rossi, with whom both Prof. Lust and myself worked at MIT, used to say that Prof. Lust had his solar wind probes in the sky much earlier than anybody else. So it is very fitting that the GIOTTO mission and its successful completion took place under Prof. Lust's regime. Prof. Lust was also, in a way, associated with us when the first solar wind probe of MIT went up on EXPLORER 10.



"Everything that can be done without a man's presence (in space) should be done so."

Prof. Lust

Q: *So, both of you share a professional interest besides guiding the national programmes?*

Prof. Lust: Yes, I was in Trivandrum in the 1960s for the launching of sounding rockets. We launched a barium cloud experiment where the original idea was the creation of a cometary tail, but which also served for the studying of the ionosphere.

Q: *We in ISRO keep hearing about some of the ESA programmes such as ARIANE V, HERMES, COLUMBUS, OLYMPUS etc. Could you please tell us the status of ARIANE V?*

Prof. Lust: At the moment with ARIANE V we are in the so-called Phase-B, or initial phase. We hope that the initial phase will be finished by the middle of next year so that we can get a decision to start with its development phase (C and D).

Q: *What is the probable date for its completion?*

Prof. Lust: The target date for the first flight is early 1994.

Q: *We all know that you had a very successful SPACELAB mission. Could you tell us in what way the experience that you gained in this mission will be of particular relevance to the proposed space station programme with NASA?*

Prof. Lust: With SPACELAB, the first positive experiments in material science and life science were performed under microgravity conditions. However, the problem with SPACELAB is that missions last for a maximum of eight days and practically no more than five days can be used for experiments. Therefore the next step is to have long duration experiments under microgravity conditions in the material sciences as well as life sciences. The space station gives us this chance.

Q: *Last year you indicated that you would soon be placing before the ESA Member States a proposal for the Europeanisation of the HERMES Project. Could you tell us the present status of HERMES?*

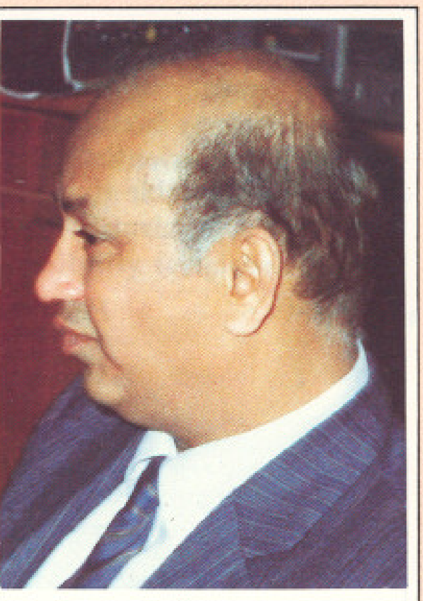
Prof. Lust: We in Europe feel that while we are participating in the space station, we also need independent access to the space station. You cannot rely wholly on American access for a number of reasons.

Q: *That reminds us of one of the resolutions passed by the ESA council namely: 'to expand Europe's autonomous capability and Europe's competitiveness in all sectors of space activity'. How far, in your opinion, has ESA progressed towards this?*

Prof. Lust: Yes, we have progressed. Europe is autonomous in the launching of unmanned spacecraft, and developing satellites for scientific research, telecommunications and earth observations. We are not autonomous yet for manned missions. There we rely on the Shuttle and therefore we really need another vehicle. This is HERMES. HERMES has been proposed by France, but the Rome Ministerial Conference decided that HERMES will be looked upon as an European project. In the meantime, the ESA Council has accepted the HERMES Project for the preparatory phase.

Q: *Where does it put HOTOL?*

Prof. Lust: HOTOL is a very interesting proposition by the UK, namely to launch in a horizontal way. Its engine is air-breathing and then works like a rocket; but it is a single engine. We feel that HOTOL will come only after the year 2000 AD. This and another project which has been proposed by Germany, called SANGER, are for the generation after HERMES. We also feel that first we have to learn all the problems in aeronautics, supersonic flight, re-entry and so on before we really can embark on HOTOL or SANGER or any other similar project.



"Whereas scientific missions, by and large, can be accomplished with unmanned flights, to say that everything can be accomplished through unmanned flights is not right."

Prof. Rao

Q: *In this context, we shall address a question to both of you. Authorities like Prof. Van Allen have expressed a view that manned missions have starved space research in general. Do you agree with this? What are your views on this subject?*

Prof. Lust: One has to distinguish between different fields in science which want to make use of space. There is traditional space science such as astronomy, astrophysics and upper atmospheric research. From the beginning, these missions have been carried out unmanned. For all these missions there was a need for pinpoint accuracy. Certainly here man is not useful; he is in fact a disturbing factor. But if you take microgravity research, which is still in the exploaratory stage, many things can be done automatically or by robotics. Men are needed in space when there is question of servicing certain satellites, such as the Hubble Space Telescope, which should last for 20 years or if you take infrared astronomy. Doubtless, everything that can be done without a man's presence should be done so and the development will go towards robotics. Therefore, I suggest there is an equation here, or a right way of budgeting so that the manned mission does not eat up all the money. One should really be fair when one makes a judgement on the manned missions.

Q: *Prof. Rao, could you tell us your views on this?*

Prof. Rao: I agree with Prof. Lust. What my friend Van Allen says is, to some extent, true; with the emphasis on manned flights the amount of money which has been available for large space missions has gone down. But this is a question of budgeting. Whereas scientific missions, by and large, can be accomplished with unmanned flights, to say that everything can be accomplished through unmanned flights is not right. For example, Prof. Lust talked of servicing of satellites which demands human presence in space. Microgravity and biological experiments are other such areas. These are the areas where we might in distant future carry out experiments using robotics. But today, in the beginning stage, human presence is essential to carry out such experiments. I also foresee the space stations essentially leading some day to space manufacture and, if that is the case, there is certainly going to be a thrust for manned flights.

Q: *We have come a long way from the so-called space exploration to space exploitation, as you yourself mentioned with space industries. Do you think that space industry can come of age within this century? If not, what, in your view, are the obstacles in the way of rapid space industrialisation?*

Prof. Lust: One should be very careful at the moment and not oversell space. The

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>
> *Prof. Rao*

public certainly will watch this very closely. As far as microgravity experiments are concerned, it might lead to production in space. We are still doing basic science experiments and not so much applied science. This is the next step, before we can speak about industry. But when we take, for instance, the field of telecommunications nobody could have predicted twenty years ago that telecommunications would be a leading field where one is earning a large sum. This is very important.

Also, one should be very careful not to underestimate its potential. Therefore, for the moment, we have to just explore the next step; in seeing what are the possibilities for learning from experiments under microgravity conditions in material sciences and biology. I would like to come back to one remark which Prof. Rao made with which I fully agree – that robotics should be used. But what I see are statements from certain people in Europe that everything can be done by robotics in space. This would sound to me like a statement that everything on earth can be done by robotics.

Q: *Prof. Rao you have any comments on this?*

Prof. Rao: Yes. Material science experiments today are, as Prof. Lust said, really in the realm of basic science. The field of application sciences is something going on now and will probably fructify. Finally, it is the cost-effectiveness that will dictate. One of the areas where one needs to do a lot of work is in building of cheaper launch vehicles. In fact, if you talk the HOTOL or any other system which uses, for example, the air-breathing concept it is essentially to reduce the cost of launching.

All one can say today is that space has tremendous potential for material processing. At least we know that the way man has been overgrazing this planet will lead over the next

50 years to exhausting a number of materials - at least 8 to 10 materials; and hence large-scale space manufacture could become a practical reality.

Q: *Prof. Lust, we understand that the first European Remote Sensing Satellite, ERS-1, is scheduled for launch sometime in mid-1989. Could you please give us some details of what this satellite would carry and what the status of the programme is?*

Prof. Lust: The development phase of ERS-1 has just started. We signed, three weeks ago, the contract with the main contractor. I hope very much that we will be able to launch in the later part of 1989. ERS-1 is so far the largest satellite project which ESA has undertaken; and also the most costly one. Its aims are observations, particularly, of oceans and for studying the interaction of the ocean with the atmosphere. The new part will be another experiment for measuring wave heights, wave motion and the earth itself through clouds. This would bring in the next step in the way of earth observation even when the earth is covered by clouds.

Q: *We expect that the experience gained by France in SPOT will automatically be exploited in ERS-1.*

Prof. Lust: As far as the optical part is concerned, SPOT will help us. I should add that I regret very much that in 1977 apparently the ESA Member States were not able to accept SPOT as an European programme. It would be certainly much better if SPOT also would be European.

Q: *We find that ESA's telecommunications and meteorological satellites have already been operationalised through agencies such as Eutelsat and Eumetsat. We also understand that in order to expand the commercial telecom market you are planning a demonstration mission called OLYMPUS for 1990s. Could you tell us something about the concept of OLYMPUS?*

> **"If we have finally satellites which make the information available to everybody and not keep it secret for military purposes, this will provide a possibility for global peace."**
>
> *Prof. Lust*

> **"The problems related to weather, environment, climate etc. are not problems of a particular nation but of the entire world. What affects the entire world has to be tackled globally."**
>
> *Prof. Rao*

Prof. Lust: Yes, ESA is an organisation for development mainly and not really for operations, with the exception of science. It was a policy in Europe that as soon as an area did become operational certain other agencies should take over.

In the field of telecommunication the PTTs (National Mail and Telephone Companies) formed Eutelsat and now, since METEOSAT is operational, a new organisation, Eumetsat, has been formed. OLYMPUS is the next step in the field of telecommunications. The experience which we have, atleast in Europe, is that the PTTs are very conservative. One has to convince them by experiments. This was done with the first communications satellite by ESA and now we are trying to do with OLYMPUS the direct television transmission. I hope, when this is successful, that Eutelsat will take over this activity too.

Q: *Coming to Space Science. We read a statement made by you a couple of years ago: 'Space Science has lacked a long term programme and potential recruits to this branch of science have not necessarily seen an acceptable career ahead of them.' Do you think that the situation has improved now?*

Prof. Lust: I think it has improved considerably in Europe. There is a presentation of a long-term plan called "horizon 2000", so that the scientific community knows what is coming for the next 15 years. What still worries me is that the frequency of space science projects is still very low. A young scientist has to wait a considerable time before he gets scientific results. The worst example is our research project, the so-called solar polar mission, which due to the Challenger accident can be launched only by 1989 or even 1990. The mission had started, if I am not mistaken, in the beginning of 70s. It is nearly 20 years and this certainly is too long.

Q: *Prof. Rao, would you like to comment on this?*

Prof. Rao: Well, this is very true and we have in India an even more difficult problem. The gestation period for making a good experiment, even if the entire infrastructure is available, is of the order of 4 or 5 years. Talking of more complex missions it could be anywhere between 8 to 10 years. Part of the problem is to motivate the young scientist to spend a considerable period of time, however exciting it is, in pursuing space science goals. We also have to worry about resource constraints. In India, primarily due to resource constraints, our emphasis has been on applications for which there is a crying need in the country.

Q: *Prof. Lust, what do you think of our country actively collaborating with ESA in future space science missions?*

Prof. Lust: I am very much interested about this, since I know that there are very good scientists here in India. You also have now the technology available for conducting scientific experiments. We should really promote this. In our meetings here, we took the first steps in the right direction.

Prof. Rao: Yes. There are many areas in which we certainly can co-operate. What we have decided is to essentially look at the possibilities. We have also decided to establish new working groups to explore the possibility of co-operative programmes in space science. Eventually, you must realise, that co-operation between working scientists is important, and ESA and ISRO could only provide a good umbrella.

Q: *It would seem that most of the problems we face today are global in nature. For example, ecological imbalance, pollution, scarcity of nonrenewable resources etc. The scientific community believes that the solution for these problems can be obtained only through science and technology. ESA's experience shows that space technology contributed successfully towards building a United Europe. Could you speculate on how this could be extended to achieve what one may call a 'global village'?*

Prof. Lust: I think space techniques can make a very important contribution. The first step has been made in communication. We now have the means to know and understand each other better. It is taken for granted that one can see any event taking place in any part of the globe instantly. On television, for example, during the world soccer championships people were very unhappy when transmission was down for a few seconds. They demand that technology be reliable. The next step is better knowledge of our resources and to know better how the atmosphere is influencing life on Earth. This should certainly be done on a global scale. Third, is the means which we need to observe what is going on on the earth itself. It is done at the moment only by the two big powers. I think if we have finally satellites which make this information available to everybody and not keep it secret for military purpose, this will provide a possibility for global peace. I think space techniques will certainly help us in fostering peace.

Prof. Rao: Communication has shrunk both time and distance. This has happened because of space technology. Remote sensing has tremendous influence in trying to locate resources and to use the existing resources, manage them, to make sure that environmental pollution is detected and appropriate action taken. If tropical ecology is disturbed it is going to affect the entire world. The problems related to weather, environment, climate etc. are not problems of a particular nation but of the entire world. Generally, our geopolitical system lags behind the technology. I am reminded of the narrow views of politicians and their efforts to keep the news of a calamity a strict secret, as depicted in the famous fiction work 'Black Cloud' by Fred Hoyle. What affects the entire world has to be tackled globally with open-mindedness if we are to effectively avert calamities. I do hope that, even though the socio-political system is slow wisdom will prevail and the basic problems of the world will be tackled collectively for the common good of human kind as a whole☐

Partnership in Development

India SHARES her Experience

Many developing countries look at space technology as a means for improving the quality and standard of living for their peoples. Being a country that has benefited substantially in her space programme from the help provided by a number of countries, India has always firmly believed that sharing of her own experience with other developing countries would be of mutual benefit. In fact, it was this belief that prompted India to make an offer at the UNISPACE-82 to share the Indian experience in space with other developing countries. As a gesture that acknowledges the spirit of this offer, the Indian Space Research Organisation (ISRO) has initiated a programme called SHARES. Through this programme, ISRO intends to share its experience in space with others.

The scope of this programme is fairly wide; it includes training of personnel in specific areas, joint experiments using rockets, balloons, satellites and telescopes, exchange of visiting scientists, and assistance in system studies or consultancy in identified areas and so on.

The training component of SHARES programme will be initially oriented towards remote sensing, satellite communications and various aspects of video programme production development and education. For example a UN sponsored workshop entitled "Space Science and its Applications and Technology within the Framework of Educational Systems" was held at Ahmedabad during November 4-8, 1986 under this programme. 48 participants from 14 countries took part in this workshop. Progressively, based on the experience and the demands, these could diversify to cover other areas of interest. Opportunities exist for participation in some of the major programmes of ISRO, such as the Indian Middle Atmosphere Programme (IMAP) and the IRS utilisation programme. There are also possibilities for providing payload space in high altitude balloon flights and sounding rocket flights. Satellite payloads from developing countries could be flown, in the longer run, on the Stretched Rohini Series of Satellites (SROSS).

The SHARES programme is open to participants sponsored by the governments of developing countries. The emphasis will be to develop a nucleus of trained manpower in their respective countries for starting, developing or promoting activities related to practical applications of space technology. Complete details of the SHARES programme can be obtained by writing to: Chairman ISRO/Secretary, DOS, Cauvery Bhavan, Kempegowda Road, Bangalore-560 009 (India).

Satellite Data Available

The Indian Remote Sensing Satellite (IRS) system is a major element of the Indian National Natural Resources Information System. The space segment of the system will involve a three-axis body-stabilised sun-synchronous orbiting satellite. The ground segment will comprise facilities for controlling and operating the spacecraft as well as facilities to receive, process and disseminate user oriented information. The overall IRS programme is expected to use a series of satellites, of which the first two, IRS-1A and IRS-1B, will be identical. Later satellites in the series will carry improved sensors operating in the infrared, thermal and microwave spectrum. The IRS-1A satellite is currently scheduled for launch in mid-1987. The mission is planned for a design life of three years. An IRS Utilisation Project (IUP) to use the IRS data is also being pursued in parallel, in order to energise the applications of the remotely sensed data.

For the users of IRS five levels of data products will be available from the system. These levels represent graded improvement in processing and the accuracies. Thus the level '0' or the Quick Look Product will be generated at the Data Reception Station after a payload operation pass. The only corrections applied are sun elevation and earth rotation corrections. The level '1' or Browse Product will be generated after radiometric corrections. The level '2' or Standard Product will be generated after correcting for line/pixel dropouts, radiometric errors and geometric errors. The level '3' or Precision Products will be similar to the standard products with the addition of precision processing using ground control points. The level '4' or Special Products will incorporate various enhancement techniques such as contrast stretching, edge enhancement, band rationing and principle component analysis.

In keeping with the spirit of the offer made by India at UNISPACE-82, IRS data will be made available to other countries. Two options will be available to countries desirous of receiving IRS data. One is to receive processed data over their territories directly from the Indian station at Hyderabad. The other is to augment an existing or planned LANDSAT-D or SPOT data reception station that may be already available with a user, for IRS data reception. One could, of course, set up a new IRS data reception facility also. Adequate assistance will be provided by India for achieving these capabilities.

The complete details of the Indian Remote Sensing System as well as those of the procedures for obtaining the IRS data products have been published in the form of a document entitled *Announcement on the Availability of IRS Data*. This publication can be obtained by writing to:
Chairman, ISRO/Secretary, DOS,
Cauvery Bhavan,
Kempegowda Road,
Bangalore-560 009 (India)☐

Prof. Kerstin Fredga and Prof. U.R. Rao, during their meeting at Bangalore.

Co-operation with Sweden

ISRO and the Swedish Board of Space Activities (SBSA) signed a Memorandum of Understanding (MOU) on October 31, 1986 in Bangalore. The MOU provides a framework for collaborative activities in the development of space technology and applications. SBSA has the principal responsibility for government-funded national and international space efforts in Sweden. A delegation headed by Prof. Kerstin Fredga of the SBSA, met Prof. U.R. Rao, Chairman, ISRO in Bangalore, in this connection.

The MOU between ISRO and SBSA covers the areas of common interest in the field of utilisation of TTC facilities, use of satellites for global peace keeping, applications of remote sensing to forestry, agriculture and environmental monitoring and selected technology elements such as microwave remote sensing. An outcome of the recommendations of the Indo-Swedish joint commission in science and technology, the MOU is based on the common approach of India and Sweden to confine the use of space technology to peaceful purposes. The MOU is expected to further common interests and facilitate the interchange of information, technology and personnel in areas of mutual interest. It is also one more step arising out of ISRO's recognition of the advantages and benefits of international co-operation in Space□

November 1986: Quality Month

In order to spread the concept of quality maintenance and to inculcate a sense of quality awareness in the minds of both the consumers as well as the manufacturers, it was proposed by the Government of India, that the month of November 1986 be observed as Quality Maintenance and Improvement month. During this month seminars, exhibitions, workshops etc were held throughout the country to discuss and disseminate information on all aspects of quality, reliability and productivity.

A well-entrenched reliability and quality assurance (R&QA) culture exists in ISRO, as it should be. In keeping with the mood of the quality month several programmes were undertaken by the R&QA groups of the ISRO Centres, laying stress on self-scrutiny. These included conduct of seminars and lectures by specialists, release of R&QA publications, exhibitions of technical reports and standards, issue of special posters and technical reviews of R&QA activities. To cite a few examples: a three day course on 'Quality Aspects of Launch Vehicles' was conducted at the Vikram Sarabhai Space Centre (VSSC), Trivandrum; a detailed 'quality review' of SHAR Centre activities was taken by Director, SHAR; a bibliography of quality assurance publications was brought out at the Space Aplications Centre (SAC), Ahmedabad; a one day R&QA seminar was arranged at the ISRO Satellite Centre (ISAC), Bangalore; a special publication entitled *Quality and Reliability of Space Systems* was released at a function in ISRO HQ, Bangalore. Film and slide shows were also arranged at all the Centres□

Space Establishments

A panoramic view of the Vikram Sarabhai Space Centre (VSSC), at Trivandrum from the Veli Hill side. A model of the ASLV is in the foreground. VSSC is India's premier centre for space technology. The SLV-3 was designed and developed here. So is the ASLV.