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Indian Space Programme

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The paper provides an overview of the evolution of the Indian Space Programme right from the days of modest but well conceived experimental efforts during the early 60's to the present day of operational and quasi-operational space applications. The organizational structure and the systematic steps by which this growth has been accomplished through the phases of learning, experimentation and operationalization are presented. The significant achievements, in each of the major areas viz., the launch vehicles, space-craft, support facilities, space applications and data products are also brought out along with the technological spin-offs. The action plan for the immediate future in each of the areas has also been outlined which eventually paves the way for achieving self sufficiency in the field of space technology.

1 Introduction

With modest start in early sixties, the Indian Space Programme has now matured to an operational and quasi-operational stage. From the very inception, the emphasis in the Indian Space Programme has been on the application and utilization of space technology for national developmental tasks with gradual indigenization for achieving total self-reliance in the long run. Way back in 1964, when a decision was taken to set up India's first Satellite Communication Earth Station [ESCES] or in 1962 when establishment of Thumba Equatorial Rocket Launching Station [TERLS] was set up, this aspect has always been at the back of our mind. TERLS activities were principally oriented towards application to space sciences and the decision to set up ESCES was taken to explore the potential of outer space and artificial satellites in the field of communications and broadcasting for the country. Incidentally, in 1964, no operating satellite-based communication systems existed in the world. We have had some experiments only — though epoch making in this direction — using Telstar and Relay satellites.

In practical terms, harnessing of space for national developmental tasks involves:

- Use of space for communications including mass communication such as TV, radio, etc.
- Use of space for remote sensing including meteorology to sense, collect, process and disseminate the resource and weather data for effective use in planning, monitoring, development and exploitation of natural resources.

To realize the above goals, we need the capability to:

- Effectively and efficiently utilize the communciations and remote sensing capabilities provided by satellites
- Design, build and operate communications and remote sensing satellites
- Launch the satellites with our own launchers

ISRO has been striving to achieve this for over twenty years and during this period our activities have gone through three distinct phases.

First phase, which covered the period of 1960's, was our learning phase. During this period we established laboratories, collected and trained manpower by undertaking R&D tasks and took up initial developmental activities directly connected with space such as development of sounding rockets and associated payloads.

Second phase of our activities spanned the period 1970-1980. During this period major experimental projects for the development of space technology, oriented towards applications and appropriate hardware realization, were undertaken. We had major applications-related experiments such as SITE and STEP in the field of satellite-based communications and broadcasting. We developed our own satellite launch vehicle SLV-3, which placed 40-kg Rohini Satellite into low-earth orbit and we developed a series of satellites for different applications such as Aryabhata, Bhaskara-I, Bhaskara-II and APPLE (which was a geo-synchronous satellite for communications). In the field of remote sensing, satellite- and aircraft-based remote sensing activities were started in a major way with the setting up of various facilities at NRSA and SAC. We have had a very close interaction with the user agencies in these areas and most of these experiments were planned along with them. We involved industry to a reasonable extent in this period to deliver various types of hardware indigenously.

In the current decade, we are entering into operational and quasi-operational phase of space applications. We have INSAT-I series of multipurpose satellites for communication and meteorology. In the area of remote sensing, we work with LANDSAT and NOAA satellites and propose to work with SPOT satellite for obtaining imagery over the Indian region. Indian Remote Sensing Satellites (IRS) and INSAT-II series of satellites will be launched during this decade. We have taken up major developmental tasks to upgrade our launch capability so that we will be able to launch our operational remote sensing satellites before the end of this decade.

During this presentation, I will try to give a brief exposure to the different components of the Indian Space Programme.

The Department of Space (DOS) is responsible for the execution of space activities in the country through the Indian Space Research Organisation (ISRO). Fig. 1 gives the organisation chart of DOS/ISRO. Fig.2 gives the location of different establishments of the Department of Space.

2 Overview of Past Activities

2.1 Space Applications

A major thrust was directed towards the space applications right from the very beginning of space activities which started in early 60's.

Communication

In the field of communications and broadcasting, activities were initiated with the setting up of ESCES in 1967 which was followed by setting up of the first operational satellite communication earth station for overseas communication via INTELSAT at Arvi near Poona with indigenous efforts. We have had a number of studies conducted for evolving the optimum satellite-based multiple application system for the country covering communications, broadcasting and meteorology. These studies provided very useful background in defining the INSAT system. These studies were followed by large scale and varied experiments spread over a period of years using active satellites for gaining operational experience and validating the system concepts. Satellite Instructional Television Experiment [SITE] using NASA's ATS-6 Satellite, Satellite Telecommunication Experiment Project [STEP] using Franco-German SYMPHONY Satellite and APPLE Utilisation Project [AUP] using our own APPLE spacecraft, are examples of these major experiments, wherein we gained necessary experience and insight into the planning of these services on an operational level. In addition, these experiments have provided very valuable feedback to different user agencies who were fully involved in these projects. Fig.3 presents the activities undertaken in the field of space applications.

Remote Sensing

Starting with aerial flights in early seventies and later on using LANDSAT data, we have gained significant experience in the utilization of land survey data. All through these 15 years, we have had a very close interaction with the users. Joint Experiments Projects (JEPs) were carried out during 1970-1983 with different user agencies as well as individual scientists. Parallel efforts were made to identify central and state agencies who were already involved in the survey, identification, monitoring and utilization of natural resources. Large scale involvement of over dozen major user organizations over nearly a decade has resulted in the design of the space system to meet the practical needs and has built up sufficient expertise in various user agencies in data utilization. These studies and joint activities resulted in a seminar on the Natural Resources Management at Hyderabad in 1983 which ultimately laid the foundation for the National Natural Resources Management System (NNRMS).

2.2 Satellites

Maturity in the satellite technology and necessary confidence to take on semi-operational and operational satellites have been gained by successfully building and launching seven satellites in a phased manner with different payloads and configurations. Close association with the manufacturer during the fabrication of INSAT-I series of satellites has also given valuable inputs in this respect. Fig.4 gives the evolution of these satellites. Starting with the first technological satellite 'Aryabhata' launched in 1975, followed by Bhaskara I & II with two band TV cameras and a passive microwave radiometer and subsequently, Rohini Satellite (RS-D2) with solid state 'Smart' sensor, useful experience was gained in designing of remote sensing satellites. APPLE was our first major effort in the area of communication satellites and the experience gained in its design and fabrication is now directly contributing to the INSAT-II satellites which are currently under design and development indigenously.

2.3 Satellite Launch Vehicles and Sounding rockets

Development of sounding rockets started in early sixties and a variety of sounding rockets have been developed for various scientific and technological applications. These cover altitude ranges from 60 km to 400 km and can carry payloads from a few kilograms up to 400 kg. Development of these rockets provided very good insight into various systems needed for the Satellite Launch Vehicles (SLV). Fig.5 gives the details of various types of rockets developed so far.

Design and development of Satellite Launch Vehicle, SLV-3, was taken up in 1973 with a view to launching a small 40-kg satellite in low earth orbit. The first successful launch of a 35-kg Rohini Satellite [RS-1] took place on July 18, 1980. Subsequently two more successful flights of SLV-3 were witnessed on May 31, 1981 and april 17, 1983 which injected RS-Dl and RS-D2 satellites in near earth orbits.

2.4 Major Facilities

Setting up of major facilities which are essential for design, development, fabrication, testing and launch of satellites and launch vehicles as well as facilities required for collection, processing and dissemination of data transmitted by the satellites is an essential prerequisite in achieving any success in the space programmes. Realization of these facilities goes hand in hand with the satellite and launch vehicle development programmes. These include (a) Launch Facilities, (b) Tracking, Telemetry and Command Facilities (c) Data Reception and Processing Facilities and (d) Test Facilities.

During the past two decades, considerable effort has been put in this direction in creating these facilities which will no doubt need constant updating. A large measure of self-reliance has been achieved in realizing these facilities indigenously.

3 On-going Projects

ISRO currently has six on-going projects on hand. These are:

(a) INSAT-I series of satellites

(b) INSAT-II series of satellites

(c) Indian Remote Sensing Satellite (IRS)

(d) Stretched Rohini Series of Satellites (SROSS)

(e) Augmented Satellite Launch Vehicle (ASLV)

(f) Polar Satellite Launch Vehicle (PSLV)

Along with these projects, related facilities are being parallelly augmented and modified to meet the operational requirements. These include:

(a) Setting up and updating facilities for launch of ASLV and PSLV

(b) Upgrading of data reception and processing facilities for fuller utilization of IRS data

(c) Upgrading of facilities for SPOT and LANDSAT data reception and processing

(d) Augmenting of telemetry, tracking and command network including incorporation of S-band operation

(e) Augmentation of Master Control Facility for simultaneous handling of multiple INSAT-I and INSAT-II series satellites

(f) Setting up of NNRMS for effective natural resource management

3.1 INSAT-I

INSAT-I represents our first operational domestic satellite system which provides communications, broadcasting and meteorological services to the country. Fig.6 gives the INSAT-I system concept. It is a joint venture of the Department of Space, the Department of Telecommunications, Indian Meteorological Department, Doordarshan and All India Radio. Thus it represents not only a technical innovation for practical, cost effective enhancement of national telecommunications, meteorological and mass communication capabilities but also a major organizational innovation where different agencies are deeply involved.

INSAT series of satellites are designed to provide the following major services:

(a) Long distance telecommunication

(b) TV programme distribution and direct broadcasting to augmented TV receivers

(c) Radio programme distribution

(d) Meteorological data relay involving unattended data collection and relay platforms

The overall INSAT-I system covers the following:

(a) A space segment consisting of two identical satellites and associated mission control centre

(b) A telecommunications ground segment consisting of 34 earth stations—30 fixed and 4 transportable

(c) A meteorological ground segment consisting of a Meteorological Data Utilization Centre (MDUC), 20 secondary data utilization centres (SDUCs) distributed all over the country, 100 land based and 10 ocean based unattended Data Collection Platforms (DCPs)

(d) A radio networking ground segment

(e) A TV ground segment consisting of

(i) 2000 direct reception sets (DRS)

(ii) Uplinking facilities including transportable stations

(iii) TV ground segment consisting of 23 high power (10 kW) TV transmitters, 11 medium power (1 kW) transmitters and 133 low power (100 W) TV transmitters, along with S-band TV receiver only (TVRO) facility

The space segment consists of 12 C-Band transponders, two S-band high power transponders for TV direct broadcast service, a very high resolution radiometer (VHRR) operating in visible and near infrared bands and a data relay channel with global receive coverage in 402.75 MHz band for relay of data from unattended data relay platforms.

The spacecrafts are designed for a seven year life and are built by Ford Aerospace Communications Corporation (FACC) of USA.

The impact of INSAT-I system on the rapid growth of communications, ground segments, TV and radio broadcasting coverage and forecasting of weather has been very significant. Figs 7-11 show INSAT-I services and other connected facilities.

3.2 INSAT-II

INSAT-II spacecrafts will be second generation spacecrafts of INSAT series providing larger and better services. These spacecrafts are being indigenously designed and fabricated. INSAT-II system is configured with three operating satellites—two of these co-located at the primary operating position with orthogonal polarization diversity and the third one will be located at the major path position.

INSAT-II satellites will have 11/2 times the telecommunications capacity compared to INSAT-I satellites. These will also provide better VHRR resolution and will be able to sustain more communication channels during eclipse operation. Figs 12 and 13 give INSAT-II details.

3.3 Indian Remote Sensing Satellite (IRS)

IRS satellites to be launched into polar sunsynchronous orbits will form the backbone of Indian Remote Sensing Programme. This is a major step in developing indigenous capability in the design development, deployment and inorbit management of a remote sensing satellite capable of providing operational services for resource management in the country. A very important outcome of IRS satellite programme has been the setting up of the National Natural Resource Management system for making effective use of satellite based remotely sensed data.

IRS will be a 950-kg 3-axis stabilized spacecraft placed in a 904-km sunsynchronous orbit with a period of 103.2 min. Total country will be covered in 22 days using two day-time passes. The payload will have one LISS-I (Linear Imaging Self Scanner) and two LISS-II sensors. LISS-I will have a 73-m spatial resolution and 148-km swath. LISS-II will have half the values for the resolution and the swath i.e., 37 m and 74 km as compared to LISS-I. The coverage is so designed that two swaths of two LISS-II sensors fully cover the single swath of LISS-I, thereby providing better resolution of the imagery compared to LISS-I. Fig. 14 shows the major IRS mission elements. LISS-I and LISS-II payload sensors work in 4 bands covering 0.4-0.9 micron spectral band. The spacecraft will use S-band for TTC system and X-band (8.3 GHz) for data transmission.

National Natural Resource Management System (NNRMS)

An important step in effectively using the remotely sensed data for natural resource management for the country has been the setting up of the National Natural Resources Management System. With the accelerated developmental activities, efficient use of natural resources attains a very high priority and remote sensing programme can contribute significantly towards this goal. It must be realized that although US LANDSAT satellites have been operating for over a decade, as yet there is no fully operational natural resource management system based on remote sensing anywhere in the world. NNRMS will therefore be one of the first such semi-operational natural resource management systems. The Indian programme calls for a family of IRS satellites to be launched at approximately 2 years' interval with successive improvement in the resolution and other capabilities and eventually including microwave sensors which will give all weather and soil penetration capabilities.

NNRMS will have five regional centres located as follows:

Region	Location	Funding agency
Northern India	Dehra Dun	Dept. of Space (DOS)
Central India	Nagpur	Indian Council for Agricultural Research/Ministry of Agriculture
Eastern India	Kharagpur	Dept. of Science & Technology (DST)
Southern India	Bangalore	Dept. of Mines/Geological Survey of India
Western India	Jodhpur	DST & DOS

Regional Remote Sensing Service Centres (RRSSCs) are being set up by various Central Government Departments but establishment of lower order interpretation and analysis facilities and ground data collection will be the responsibilities of users from State Government and Central Government Departments. Quite a number of States have taken appropriate steps by establishing State centres and others are moving in the matter. Figs 15 and 16 give salient features of NNRMS system.

3.4 Stretched Rohini Satellite Series (SROSS)

SROSS will be a 150-kg class satellite suitable for launch by ASLV in 400 km near circular orbit at a nominal inclination of 44°. These satellites are well suited to meet the requirements of scientific community for small payloads. Additionally, these satellites will also be used as the proving bed for some of the new technologies that are slated for use in future IRS and INSAT satellites.

Two SROSS satellites are currently under development, one of which will carry the Monocular Electro Optical Stereo Scanner (MEOSS) payload—an earth-imaging stereo CCD camera built by the German Space Agency, DFVLR.

SROSS satellites can be configured either as a 3-axis stabilized system or as a spinner depending on the mission requirement. These will have S-band telemetry, tracking and command (TTC) and data handling systems.

3.5 Launch Vehicle Programme

Augmented Satellite Launch Vehicle (ASLV)

ASLV will be capable of placing 150-kg class satellites in 400-km near earth orbit. The first launch of ASLV is expected in early 1986. It will provide a quantum jump from the present capability of SLV-3. Fig.17 gives ASLV configuration.

ASLV has been conceived with SLV-3 as a core vehicle with minimum essential modifications. The first stage motors of SLV with canted nozzles are attached as strapons to the core vehicle to give additional thrust. The vehicle employs all solid propellant system for four stages and two strapons. The vehicle measuring 23.5 m will weigh about 39 tonnes.

The significant improvements undertaken in ASLV are the use of canted and contoured nozzles, closed loop guidance, S-band TTC and a bulbous aluminium alloy heat-shield—1 m in diameter and 3 m in length. Fig. 18 gives ASLV flight sequence.

Polar Satellite Launch Vehicle (PSLV)

PSLV is being designed to launch Indian Remote Sensing Satellites into sunsynchronous polar orbits. It will be capable of launching a 1000 kg satellite in 900 km sunsynchronous polar orbit. It is a major developmental effort which will greatly enhance our launch capability and also pave the way for the realization of geo-synchronous launch vehicles to launch the INSAT-II satellites from India.

The vehicle configuration is shown in Fig. 19. It is a four-stage vehicle configured as

$$(6 \times S9 + S125) + L37.5 + S7 + LUS$$

The first stage booster has a nominal propellant loading of 125 tonnes. Six thrust augmentation rockets (the first stage motors of SLV-3 suitably modified) are strapped on to the booster. The second stage is a Viking class liquid engine with 37.5 tonnes of usable propellant. The third stage is a 7-ton solid motor and the fourth one is a liquid upper stage with two liquid engines each of 7 kN thrust rating.

It has a liftoff weight of 275 tonnes and is 44.18 m in height.

Fig. 20 gives the flight sequence of PSLV.

3.6 Interaction with Academic Institutions

ISRO attaches great importance to the interaction with academic institutions. This, apart from involving individual scientists in various design reviews and design evaluation, is being actively pursued in the following two modes: (a) sponsored research under RESPOND programme, and (b) setting up of space technology cells.

RESPOND

RESPOND programme started in 1976 and has been reasonably active. Figs 21 and 22 give the location of various projects sponsored so far and Fig. 23 gives the break-up of various projects undertaken. Since the initiation of RESPOND programme, as many as 191 research projects, covering a large range of topics in space sciences, space applications and space technology at nearly 71 academic and research institutions distributed all over India, have been funded. So far 110 projects have been completed and 81 projects are in progress. The total support provided by ISRO for these projects is Rs 4.36 crore. On an average, Rs 60-70 lakh is spent annually on RESPOND programmes.

Space Technology Cells

In order to develop Institutional capability of space research in the long run, fully devoted space technology cells are being established in several academic centres. The first of its kind has been established at the Indian Institute of Science, Bangalore, and has been functioning since June 1982. Two more have been initiated—one at IIT, Bombay and other at IIT, Madras.

3.7 Interaction with Industry

Realizing fully well that any operational system for a large country like India needs full involvement of the indigenous industry, ISRO has been having constant interaction with Indian industry. ISRO has established memorandum of understanding with many industries which undertake our fabrication tasks on a planned basis. BEL and HAL are two such examples.

Further a conscious effort is continuously on to farm out maximum possible fabrication to industry. In 1970-75 time frame, whereas only Rs 54 crore worth of equipment was fabricated by the industry, it is expected to go up to Rs 620 crore in 1980-90 time frame.

In order to transfer the in-house developed technologies to the industry, an active Technology Transfer Group is functioning in ISRO. Figs 24-27 give details of yearwise technology transfer agreements, yearwise details on new technologies licensed, categorywise technologies licensed and modes of technology transfer from ISRO.

4 International Co-operation and Sharing of Experience in Space (SHARES)

International co-operation has played a major role in the evolution of Indian programme. ESCES, SITE, STEP, Aryabhata, Bhaskara, APPLE are major milestones in the space programme where international co-operation has played a significant role. The reception of LANDSAT data, the procurement of INSAT system, the proposed reception of French SPOT data, the IRS Launch Services agreement with USSR and a host of similar efforts in space sciences, remote sensing and TTC, represent significant gains for the programme for international co-operation. Anuradha payload flown onboard space shuttle incorporating the cosmic ray experiment of the Tata Institute of Fundamental Research, Bombay, and a TERRA experiment of mapping Indian region during the joint manned Salyut mission carrying the first Indian astronaut are further examples of successful international co-operation embarked on by ISRO. The Indian programme will continue to use available international opportunities to enhance Indian effort and understanding. At the same time, as a part of our own contribution to international co-operation, ISRO is organizing a sharing of experience in space (SHARES) programme. This programme will provide avenues for sharing the modest Indian experience in space with other developing countries.

SHARES will comprise:

(a) Training including on-the-job training

(b) Participation by engineers and scientists from other developing countries

(c) Joint experiments using Indian rockets, satellites and baloons

(d) Exchange of scientists/engineers

(e) Assistance in system studies and consultancy in specific areas

5 Future Space Programme

With the completion of ASLV, PSLV, SROSS and IRS projects, indigenous capability in building and launching 1000-kg class satellites in sunsynchronous polar orbits would be achieved by the end of this decade. With the establishment of INSAT-I system, services in communications, broadcasting and meteorology are getting operationalized in the country. The future space programme will therefore lay a major emphasis in intensifying R&D efforts in space applications in the fields of communications, resource survey and meteorology to meet the growing needs in these areas.

Indigenous development of INSAT-II class spacecrafts to replace the procured first generation INSAT-I space segment has already been started and will fructify by 1990.

Operationalization of remote sensing satellites using improved systems and techniques to get more precise data will continue to get necessary thrust. Efforts will be made in the direction of achieving higher spatial resolution typically between 10 and 15 m, and use of thermal IR band for imaging. Also R&D on microwave remote sensing for all weather resource survey will be taken up.

Launching of INSAT class satellites by indigenous launchers will call for major effort in the development of cryogenic motors and augmenting of PSLV to achieve such geo-synchronous launch capability. Various technological and other aspects of achieving this goal are now under study. PSLV growth capability is shown in Fig.28.

Fig.29 gives the profile of planned major Indian Space Missions during 1985-95.

6 Conclusion

In the past two decades, the stress has been in establishing the basic capability and the infrastructure development in the field of launch vehicles, satellites and space applications. Operational satellite-based services are now being provided in the country with INSAT-I. The primary thrust of ISRO will be to maintain and improve upon these services and at the same time gain the desired indigenous capability in meeting the future requirements of both the space and ground segments. With the completion of projects on hand, our country is poised to acquire self-reliance in building and launching advanced satellites for operational services with the complementary development of ground systems and organizations for fully exploiting the potential of space technology.

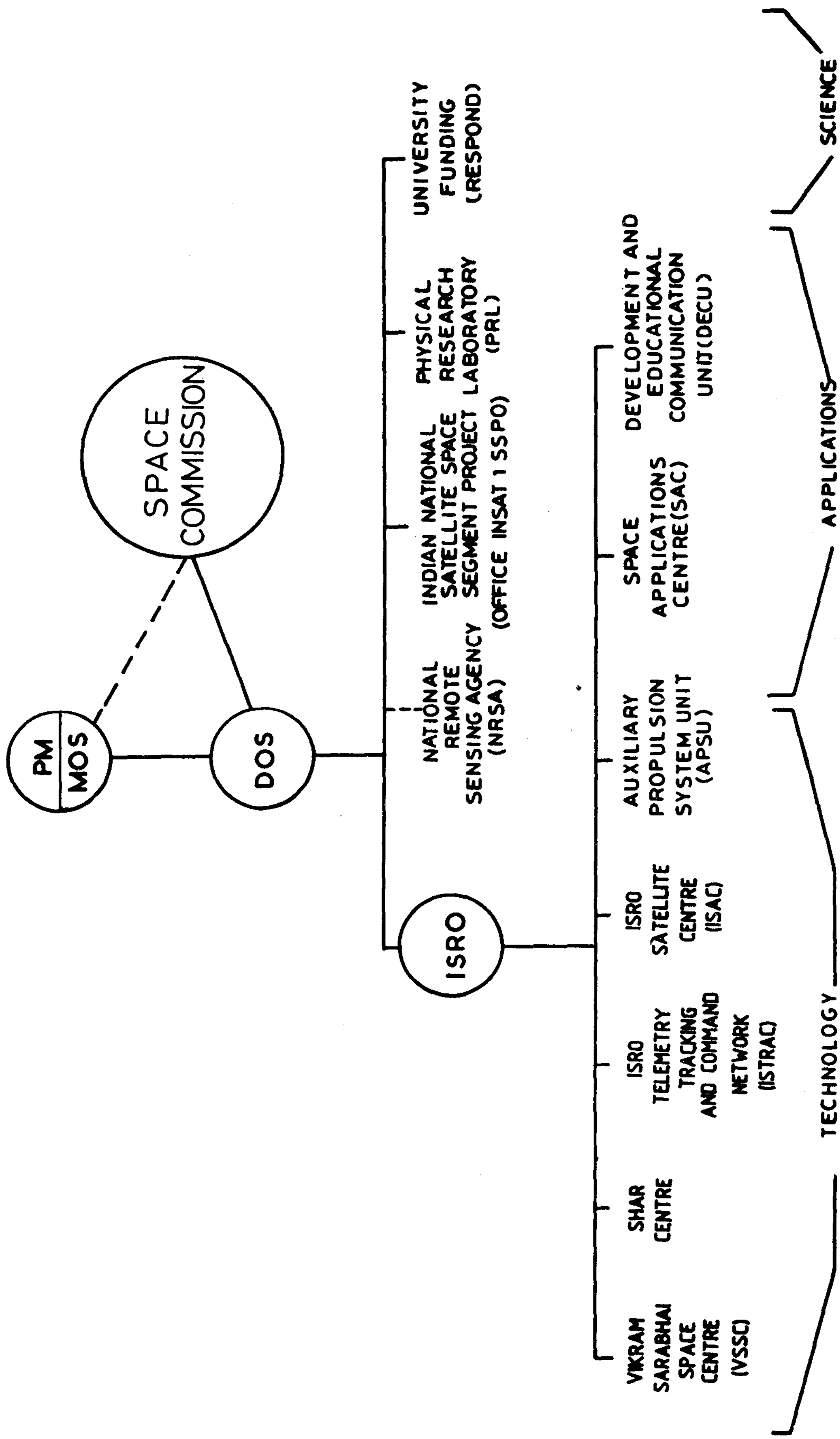


Fig. 1—Organizations of space activities

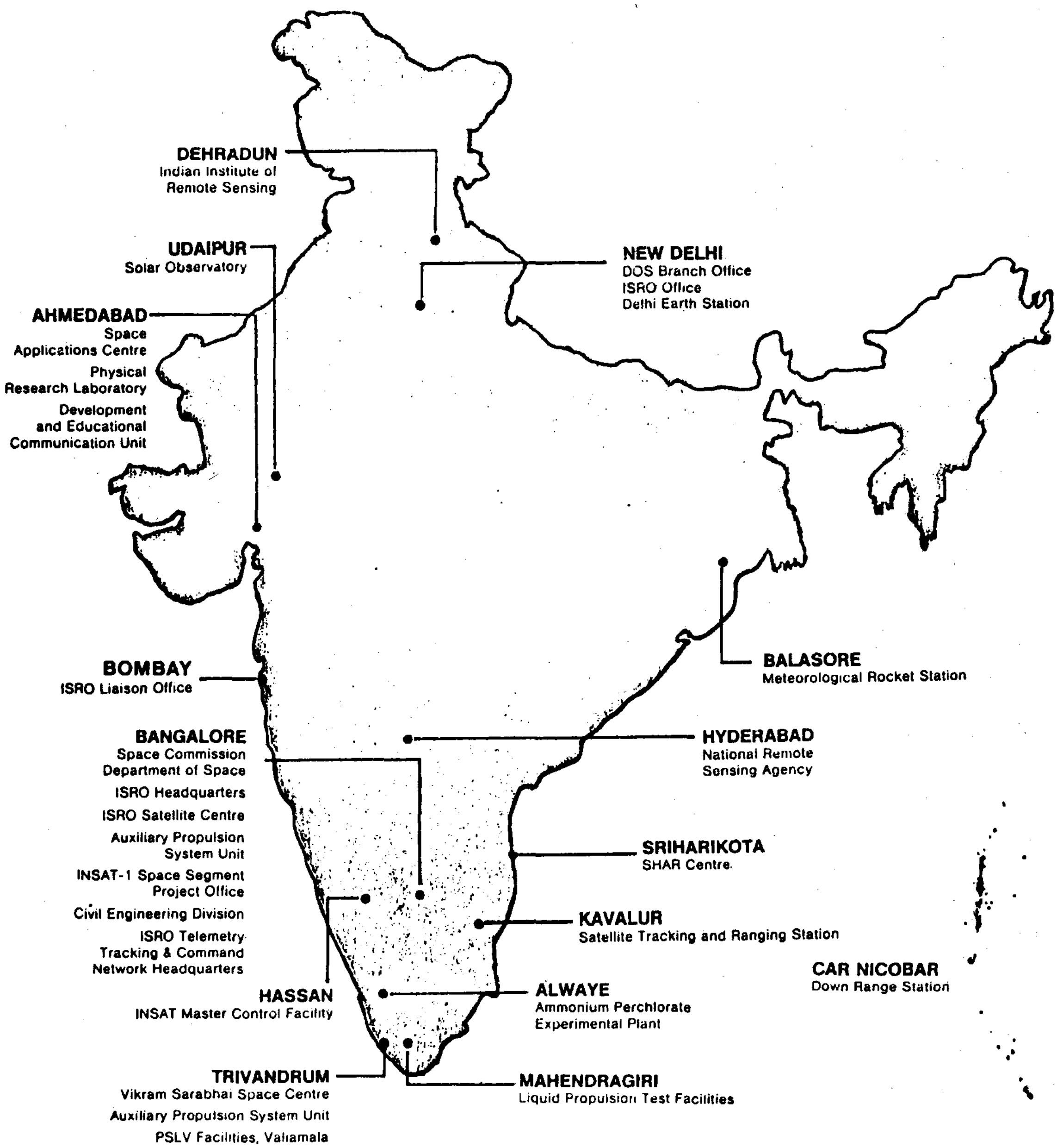


Fig. 2— Establishments of the Department of Space

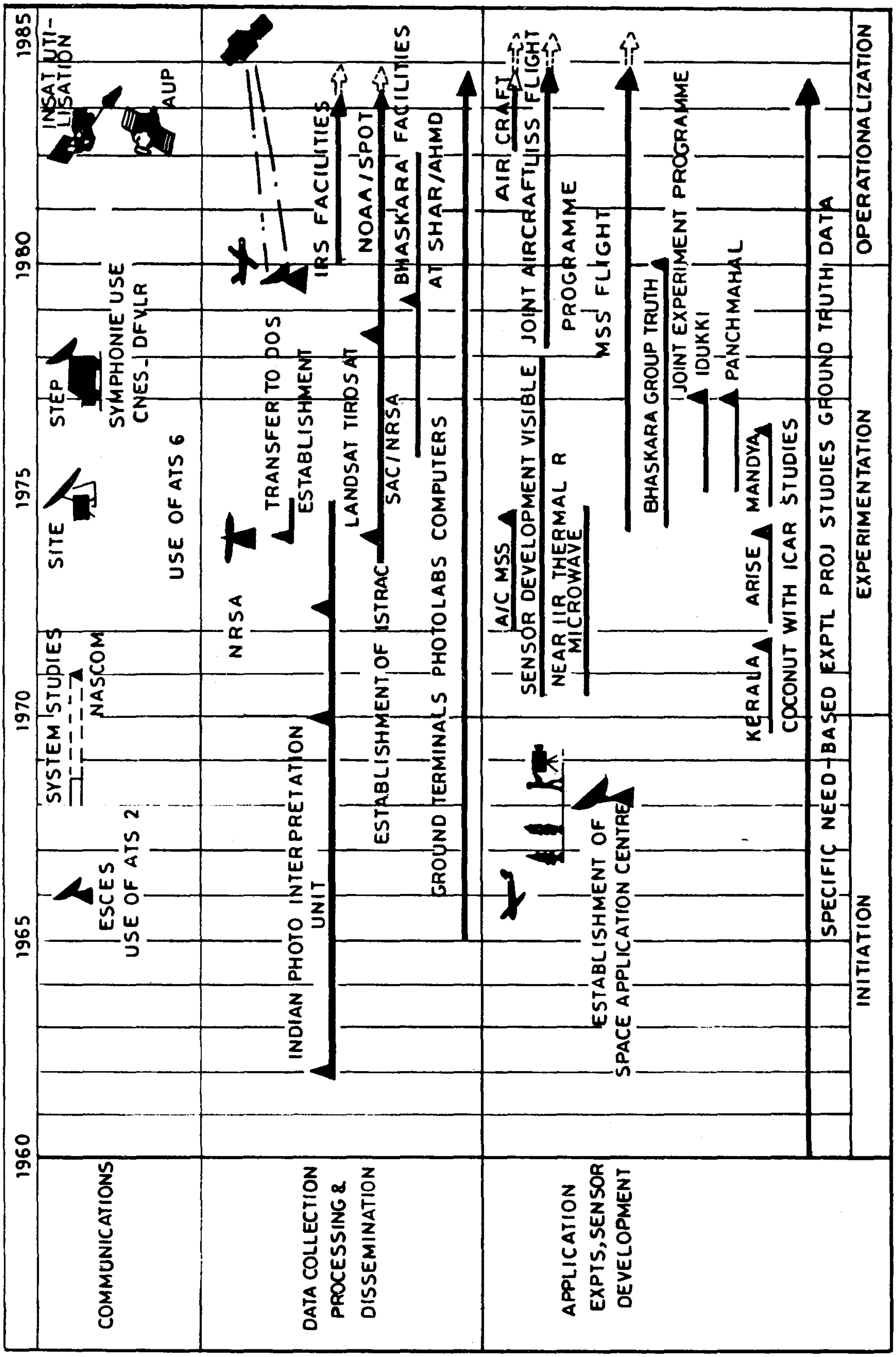
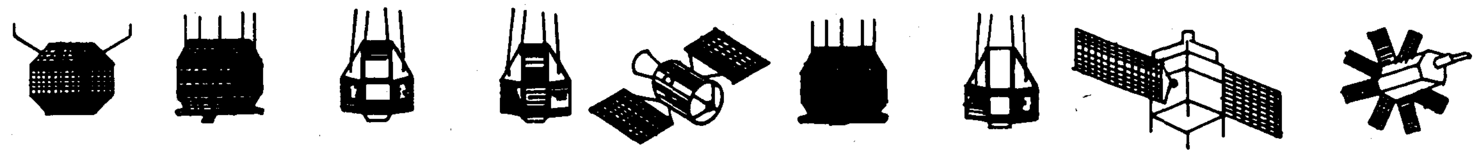


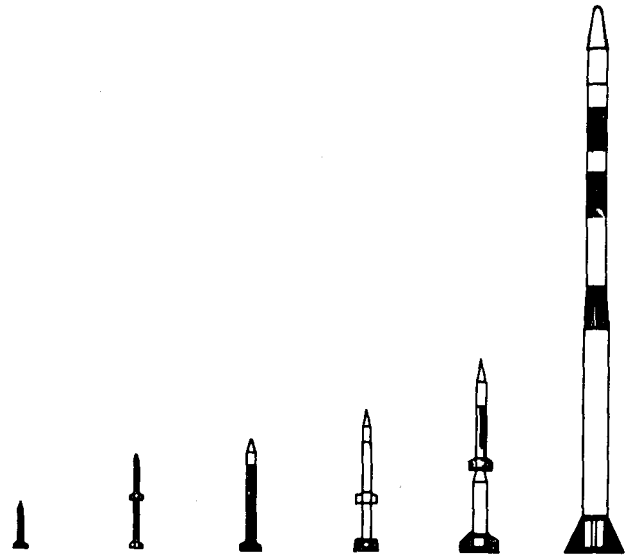
Fig. 3— Space applications (Communication, TV and remote sensing)

	ARYABHATA	BHASKARA	RS 1	RS DI	APPLE	BHASKARA II	RS D2	IRS IA	SROSS



	ARYABHATA	BHASKARA	RS 1	RS DI	APPLE	BHASKARA II	RS D2	IRS IA	SROSS
YEAR OF LAUNCH	1975	1979	1980	1981	1981	1981	1983	1984	1985
ORBIT	NEAR EARTH				GEO-SYNCH	NEAR EARTH		SUN_SYNCH	NEAR EARTH
LAUNCH WEIGHT (kg)	358	444	35	38	670	435	42	900	150
LAUNCH VEHICLE	inter cosmos	inter cosmos	SLV 3	SLV DI	ARIANE LO3	inter cosmos	SLV D2	inter cosmos	ASLV
PRIMARY POWER (WATTS)	46 AVE	47 AVE	15 MAX.	16 MAX.	280 BOL	47 AVE	16 MAX.	800 BOL	90_100
BIT RATE	2560 BPS	91.39 KBPS	325 BPS	32 KBS	64 BPS	91.39 KBPS	32 KBPS	26 MBPS	8·6 MBPS
DESIGN LIFE TIME (YEARS)	1	1	0.25	0.25	2.0	1	0.25	3	0.25
CONTROLS & STABILIZATION	spin stabilized cold gas Spinuo system 10 to 90 rpm	spin axis controlled cold gas spinrate & spin axis control magnetic Torquer 6 to 11 rpm. SpinAxis ± 3°		spinaxis controlled Magnetic Torquer 8 ± 2 rpm. spin axis ± 5	Three axis controlled Momentum wheels Magnetic Torquer Hydrazine Thruster Pitch axis ± 0.15', Roll axis ± 0.15' Yaw axis ± 0.8'		Spin axis controlled YO_YO Mechanism Magnetic torquer 8 ± 2rpm, Spin axis ± 5	Threeaxis controlled Reaction wheels magnetic Torquer Hydrazine Thruster Pitch axis 0.4', Roll axis ± 0.4', Yaw axis ± 0.5' Jitter 3X10	Three axis controlled Momentum wheels magnetic Torquer Hydrazine Thruster 0.15 on all axis Jitter 0.1m rad 50 Sec.

Fig. 4 — ISRO satellite missions



VEHICLE	RH 125	MENAKA II	RH 300	CENTAUR	RH 560	SLV
APOGEE at 85° QE in km/Orbit	11	59	135	148	390	Near Earth
Payload in kg	7	45	50	60	80	40
First Flight	1970	1970	1975	1969	1973	1979
Total Launches as on Date	64	136	18	78	28	4

Fig. 5 — Rockets built by ISRO

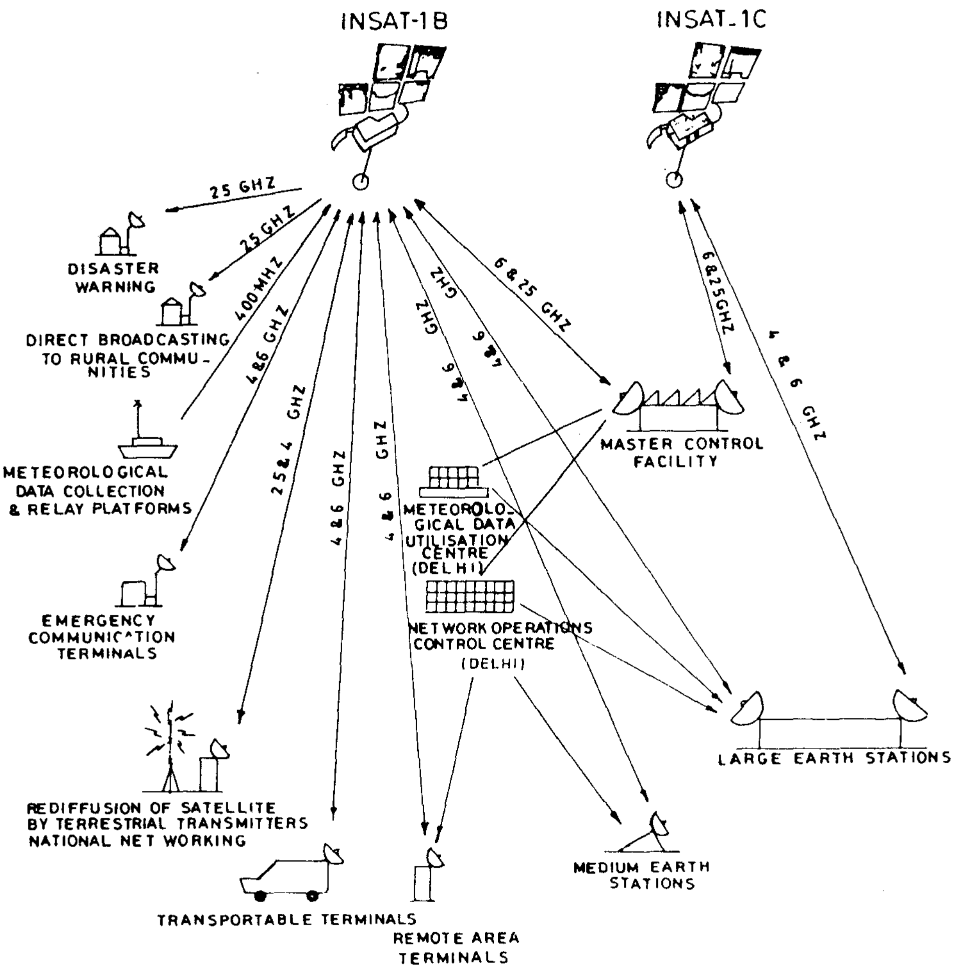


Fig. 6 INSAT-I system concept

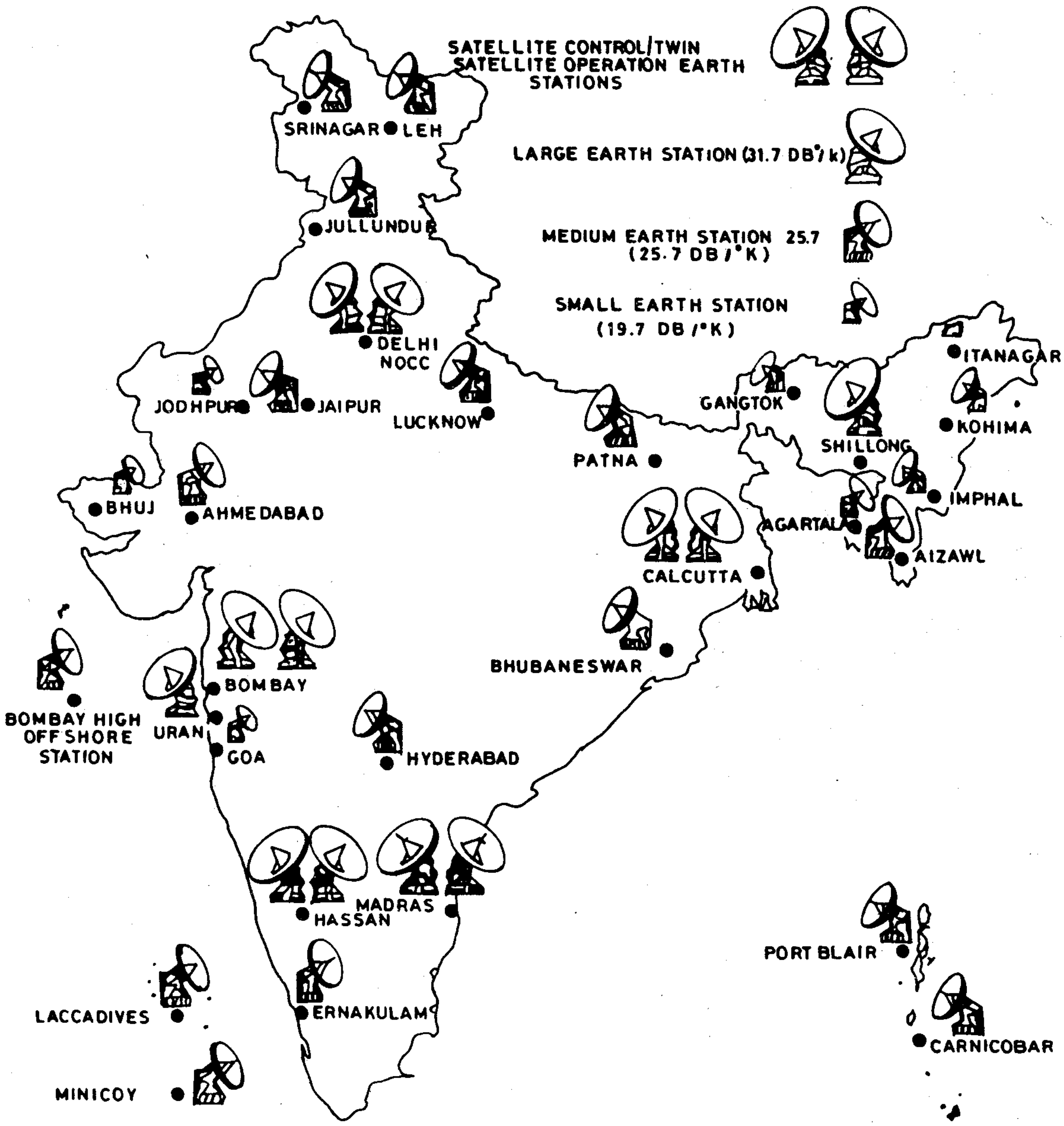


Fig. 7 INSAT-I telecommunications ground segment

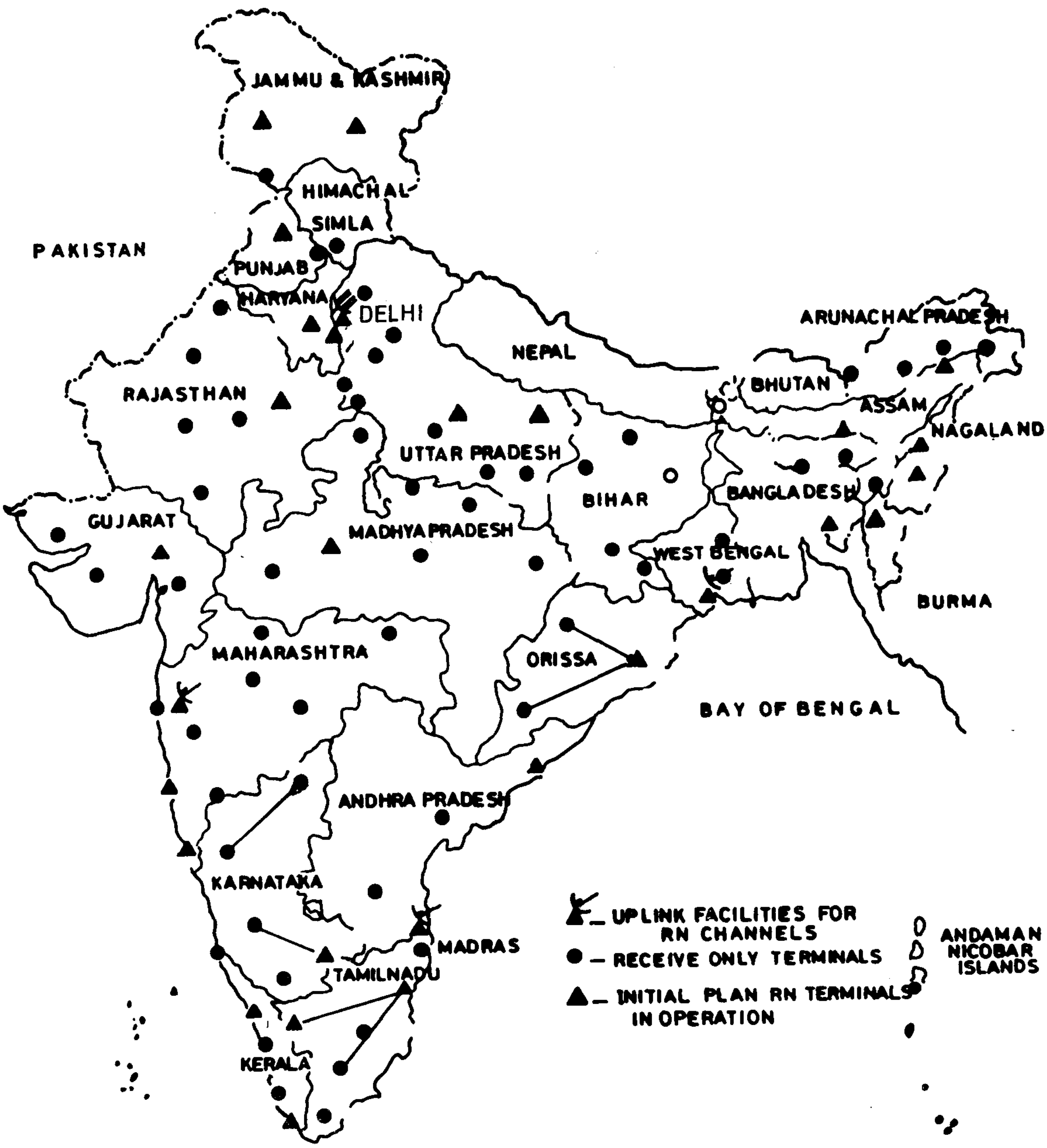


Fig. 8 Ground segment for INSAT radio networking scheme

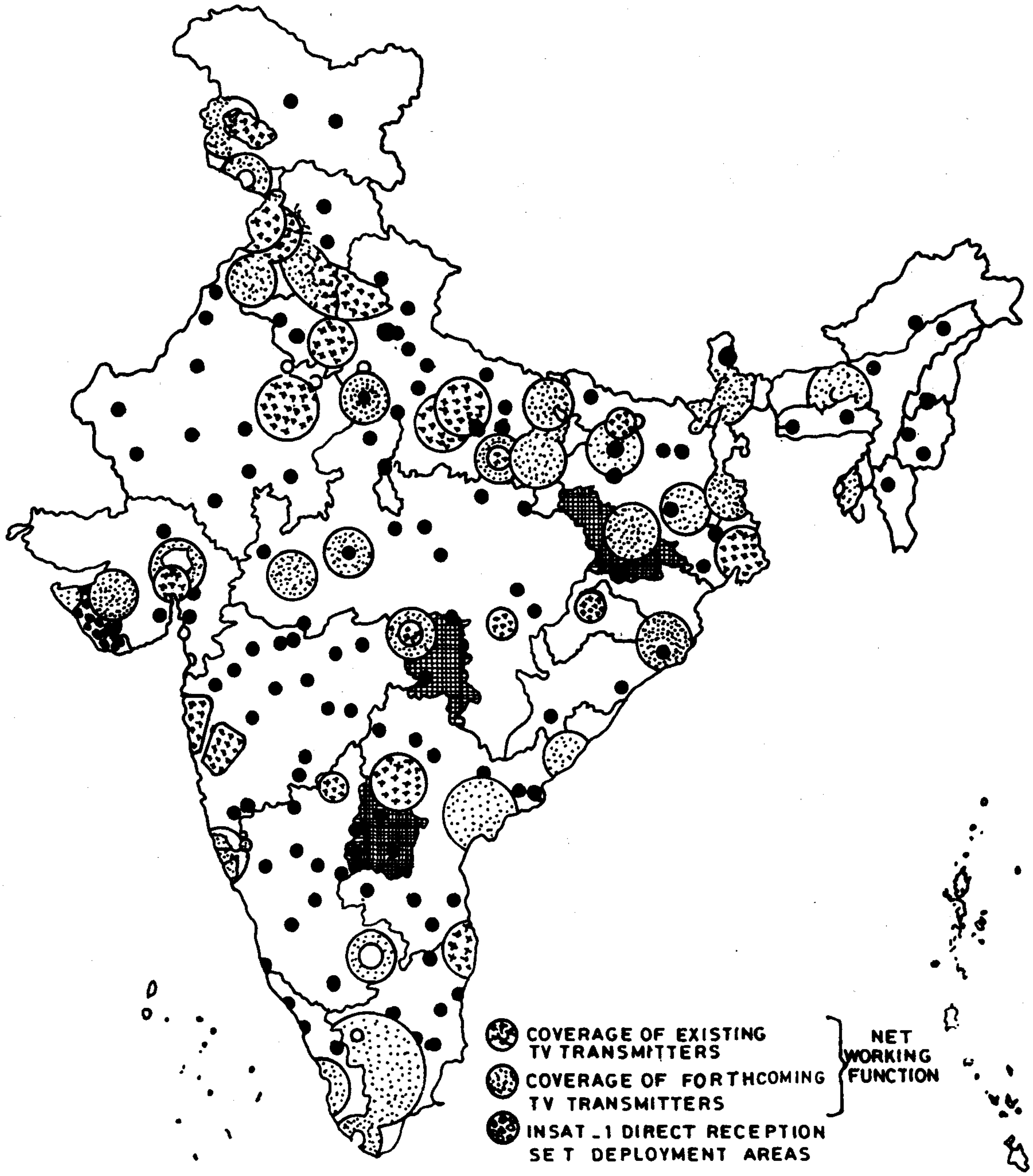


Fig. 9 — INSAT TV utilization plan 1983-87

Fig. 10 – INSAT-I meteorological ground segment

Fig. 11 — INSAT-IB VHRR imagery

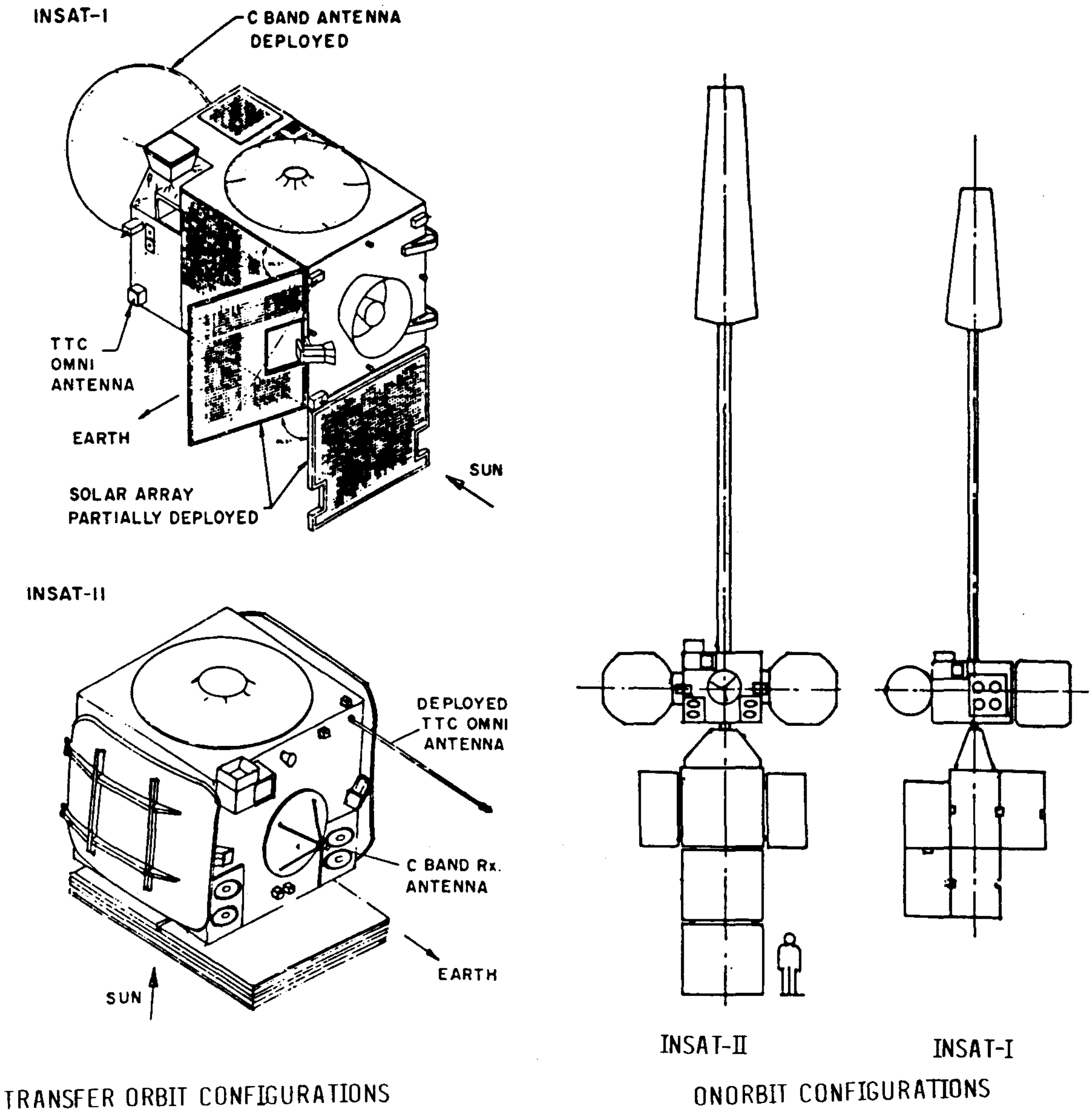


Fig. 12— Transfer orbit and onorbit configurations

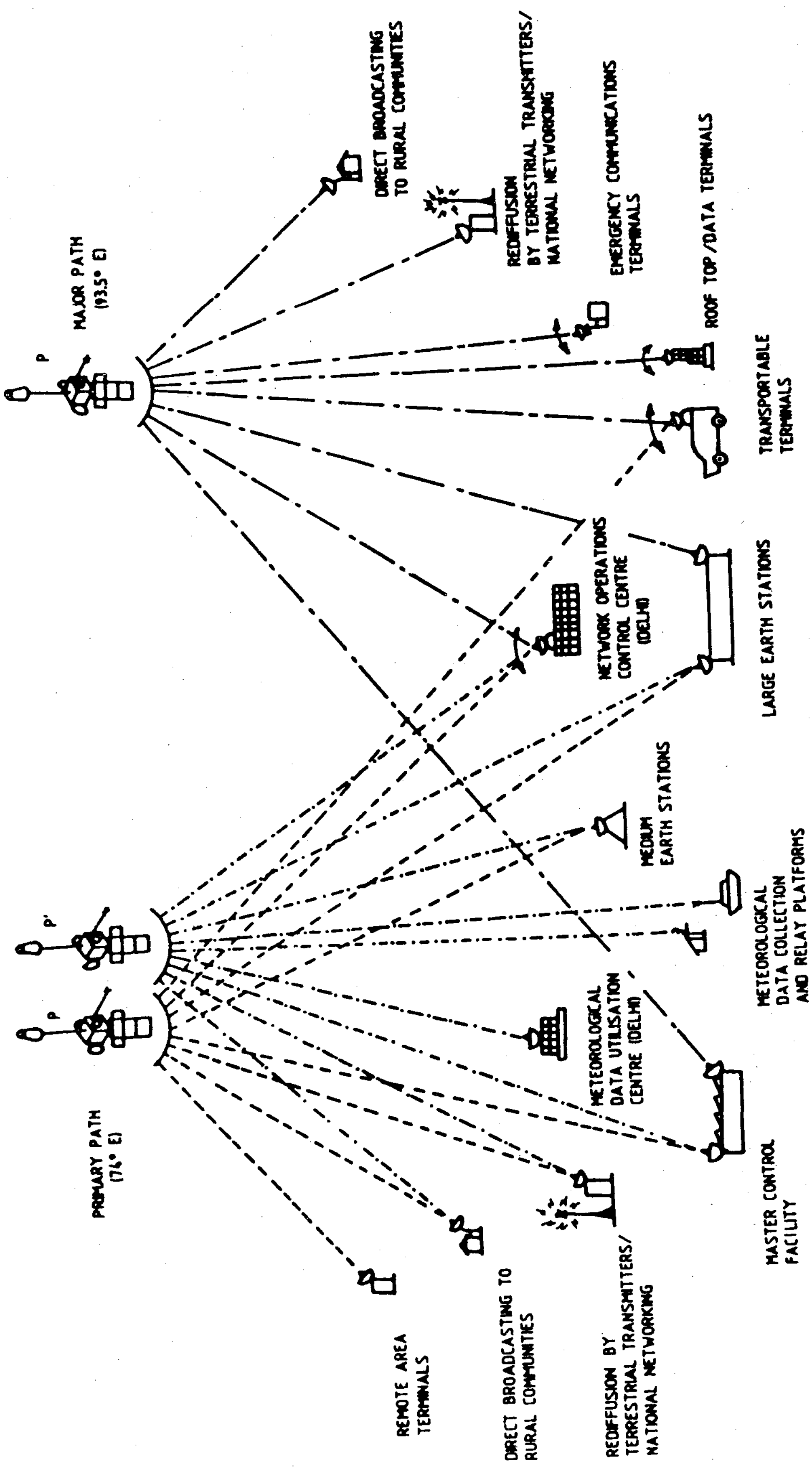


Fig. 13— INSAT-II space segment concept

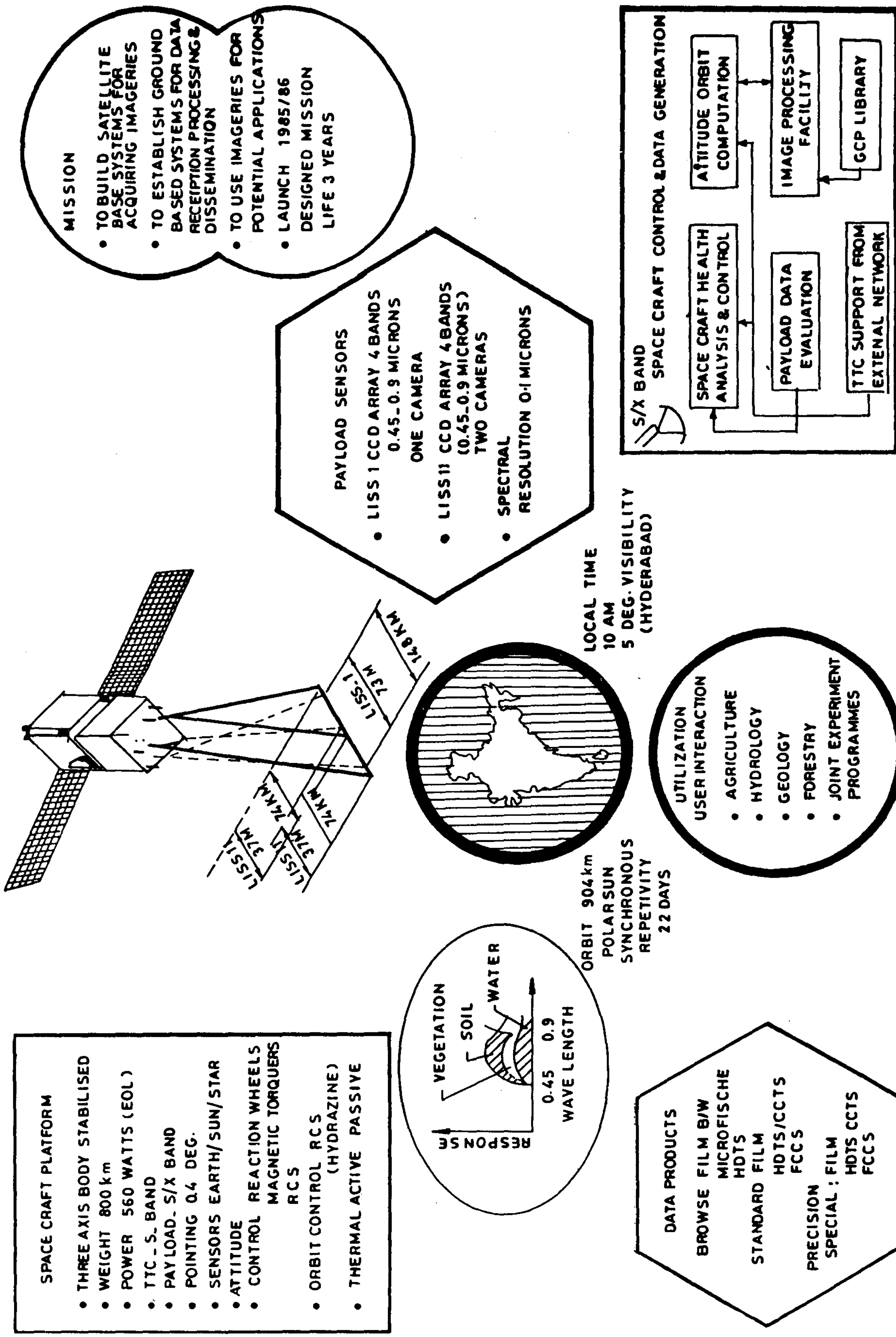


Fig. 14— IRS mission elements

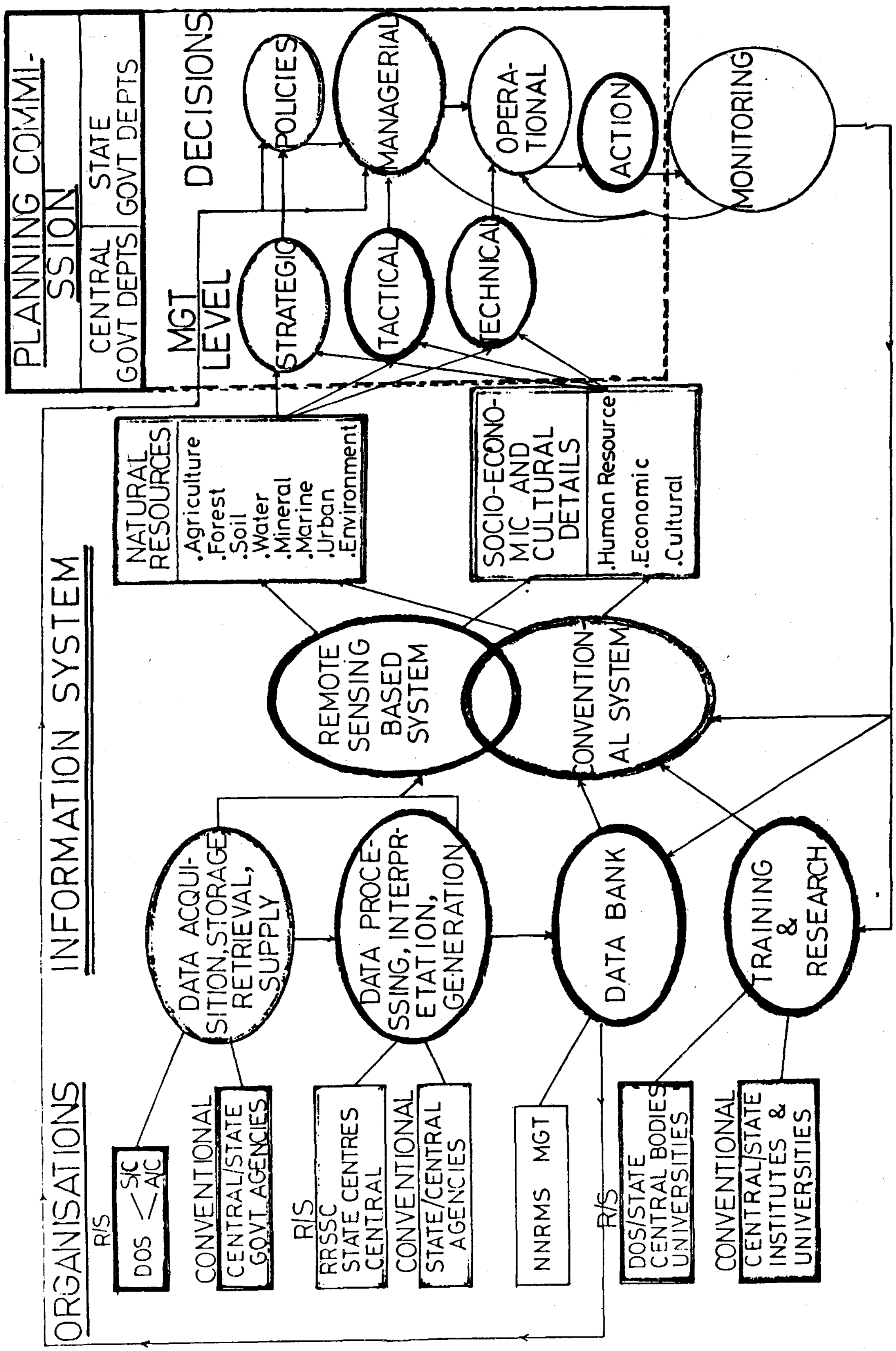


Fig. 15— National Natural Resources Management System (NNRMS)

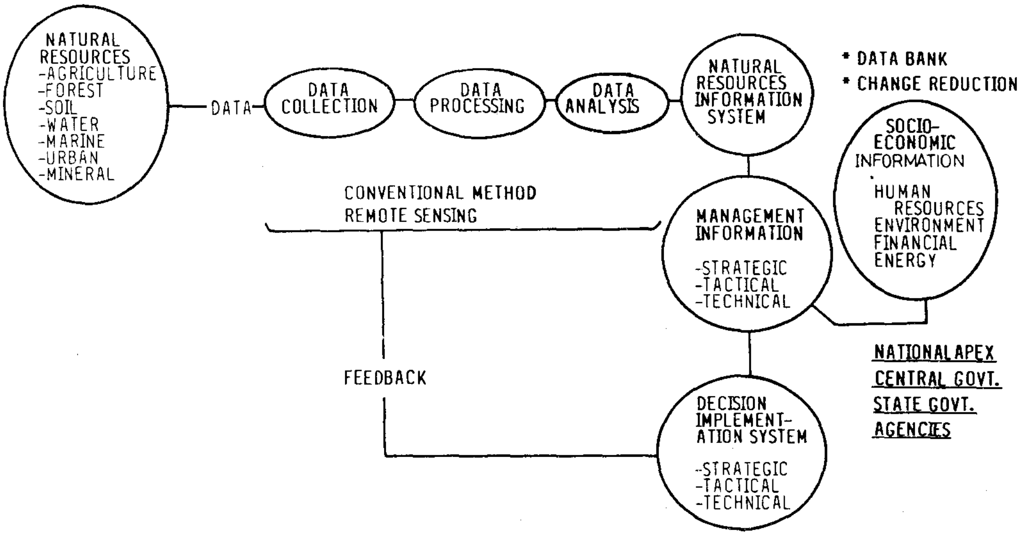


Fig. 16— National Natural Resources Management System (NNRMS)

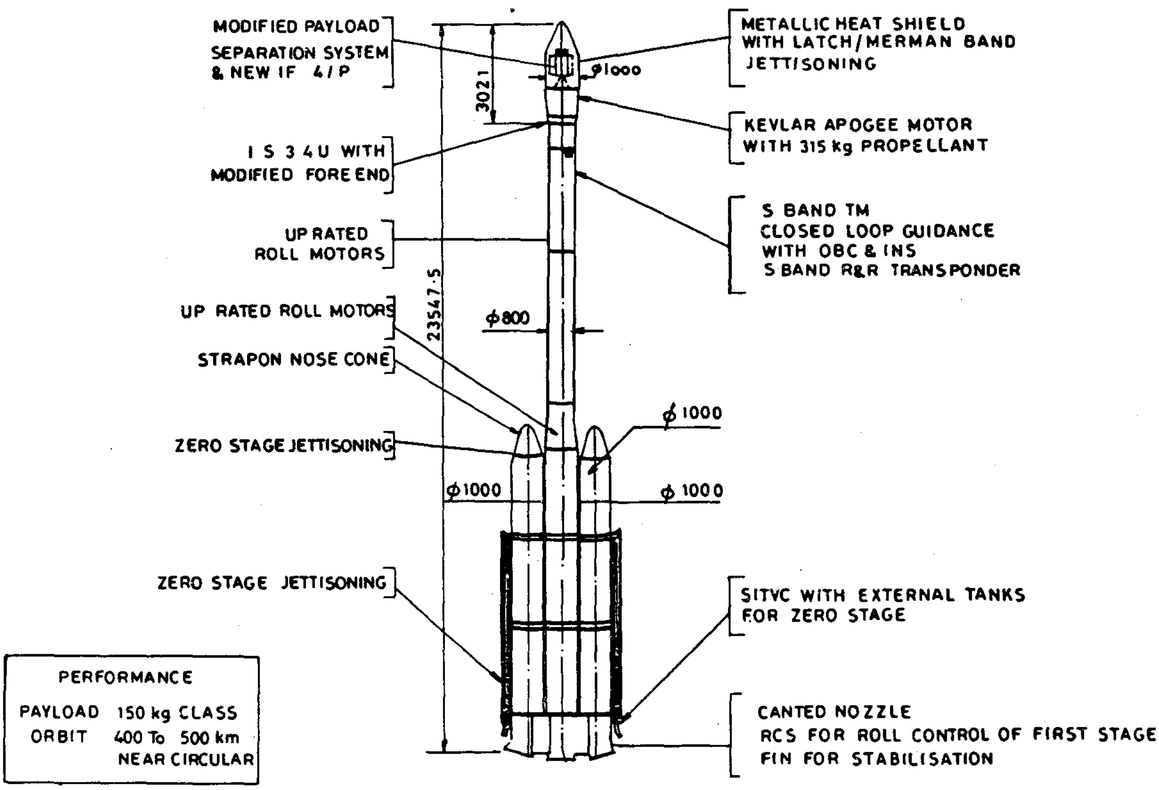


Fig. 17— Configuration of ASLV

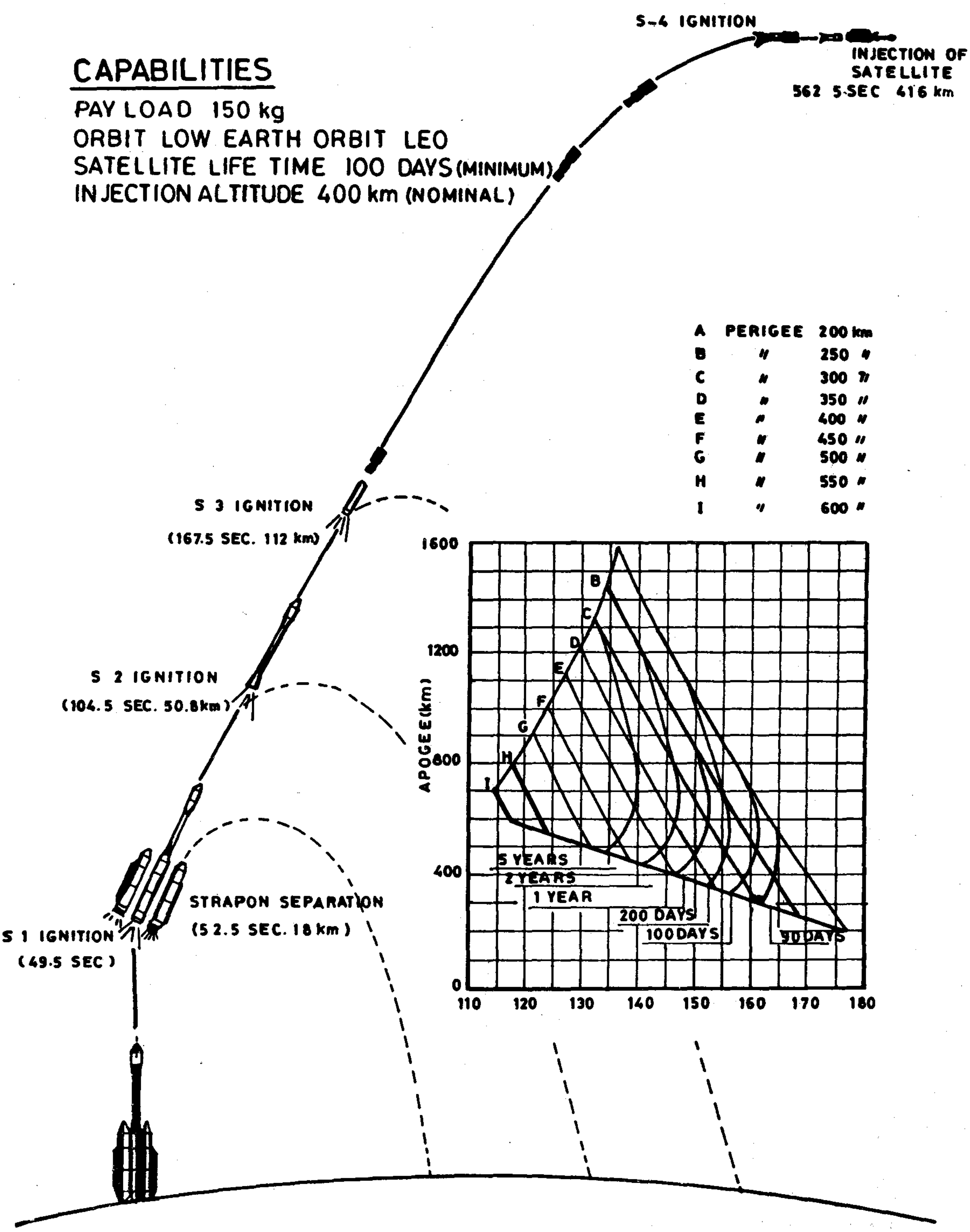
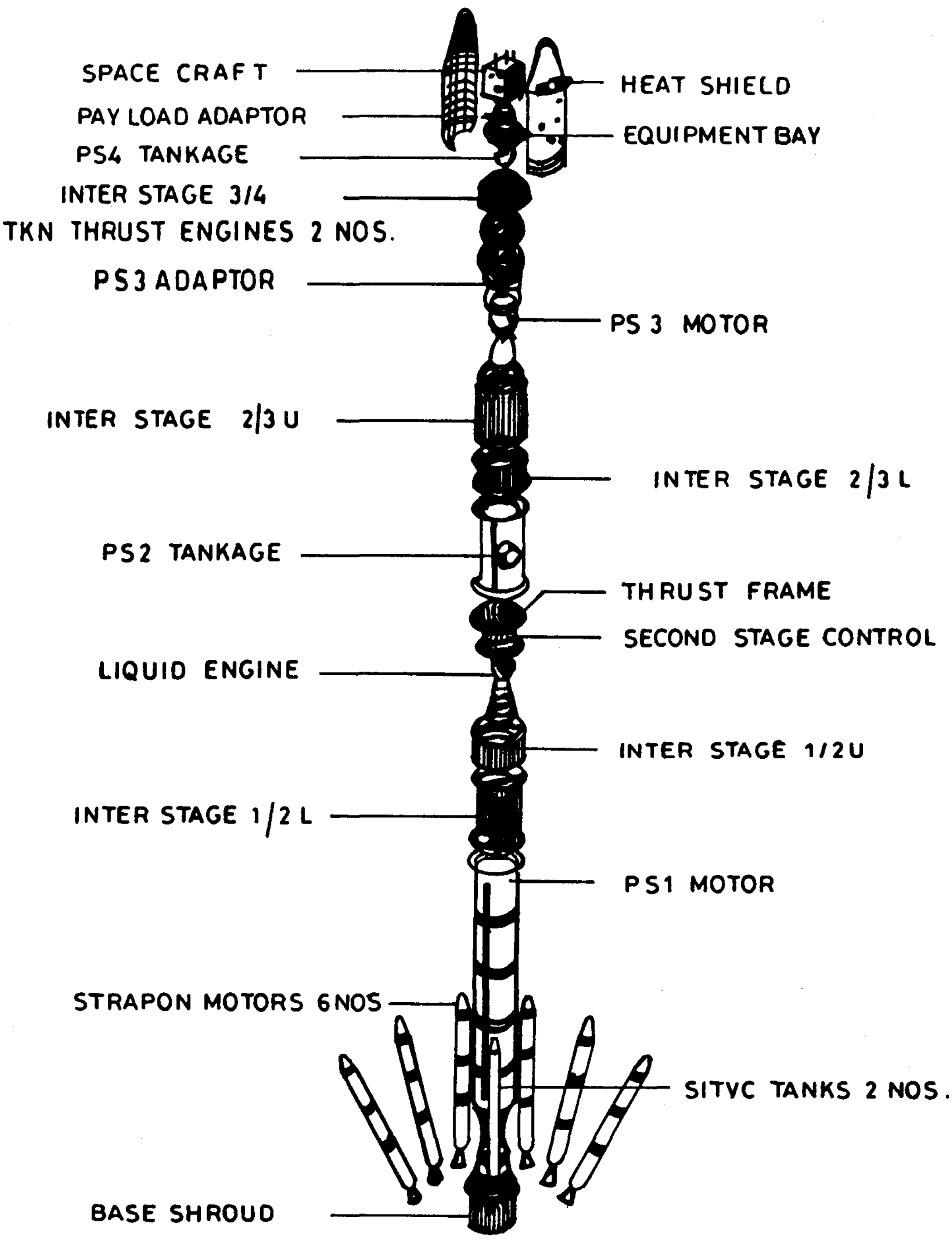


Fig. 18 — Trajectory of ASLV



SALIENT FEATURES

Pay load	1000 kg in 900 kg POLAR SUN SYNCHRONOUS ORBIT
LIFT OFF WEIGHT	275 TONNES
HEIGHT	44.18 METRES
MAX.DIA	2.8 METRES

Fig. 19 — Exploded view of PSLV

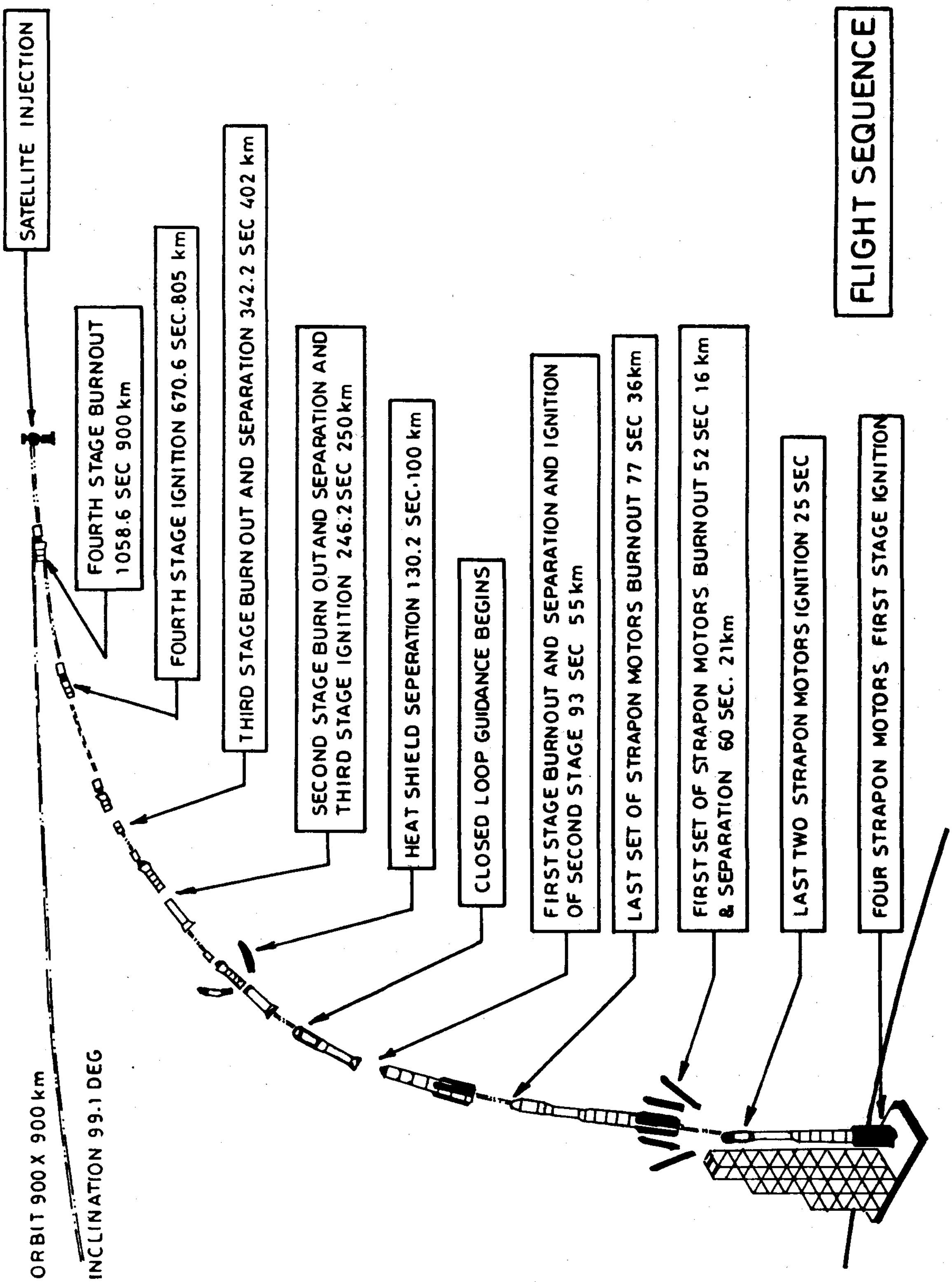
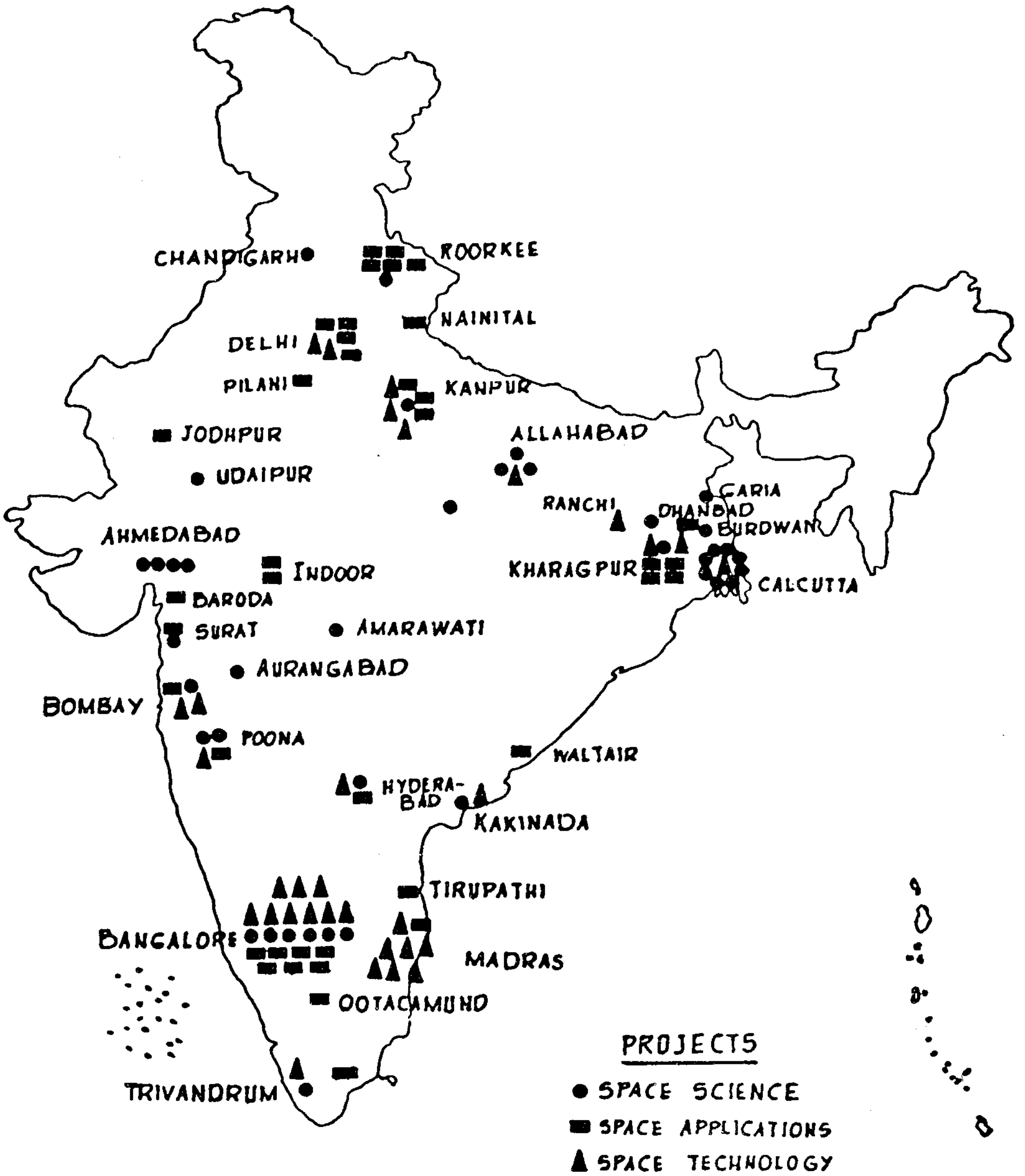
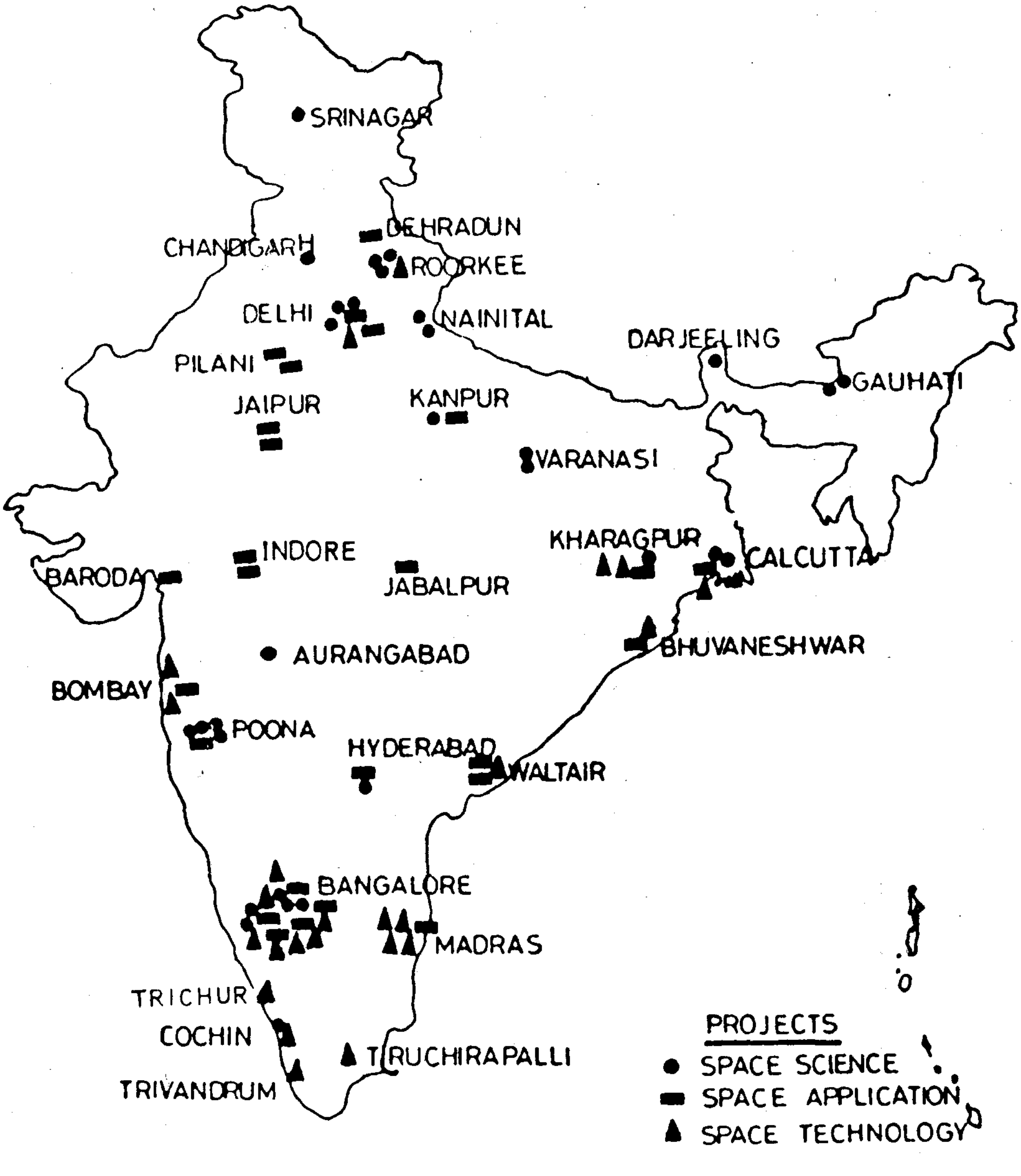


Fig. 20— Trajectory of PSLV



The distribution of RESPOND projects in the three areas for CRPs at various Institutions in the country

Fig. 21 Completed RESPOND projects (1975-80)



The distribution of RESPOND projects in the three areas for ORPs at various institutions in the country

Fig. 22 — Ongoing RESPOND projects (1980-85)

RESPOND Projects at different types of Institutions

The number of projects carried out at each type of institution in the three areas

Institutions	COMPLETED RESPOND PROJECTS					ONGOING RESPOND PROJECTS				
	Number of		Space Science	Space Appli-cation	Space Tech-nology	Number of		Space Science	Space Appli-cation	Space Tech-nology
	Institu-tions	Pro-jects				Institu-tions	Pro-jects			
Universities and Deemed Universities	28	61	24	21	16	25	49	20	14	15
Indian Institute of Technologies (IIT's)	6	25	2	10	13	5	12	3	2	7
Engineering Colleges	6	6	3	2	1	1	1	–	1	-
Research Institutions and public Sector Industries	11	18	10	6	2	13	19	8	9	2
Total ...	51	110	39	39	32	44	81	31	26	24

Fig. 23— RESPOND projects at different types of institutions

TECHNOLOGY TRANSFER TO INDUSTRIES

INITIATED IN 1976

PRIMARY MOTIVE IS THE DIFFUSION OF INDIGENOUS HIGH TECHNOLOGY TO INDIAN INDUSTRY

* SPIN-OFFS FOR NON-SPACE APPLICATIONS	: PRESSURE TRANSDUCERS, LOAD CELLS, ISRO POLYOL, DRY POWDER PULTRUSION M/C, PCM TELEMETRY SYSTEM, FEAST SOFTWARE, TV STUDIO EQUIPMENT
* FOR ISRO BUY BACK	: UDMH, ISROSIL, SPACE QUALITY SILVER ZINC CELLS
* FOR SPACE APPLICATIONS/ UTILISATION	: S-BAND DRS, EARTH STATIONS, DWS, RN TERMINAL, ELECTRO/ OPTIC INSTRUMENTS FOR REMOTE SENSING UTILISATION
* SO FAR	: 70 PRODUCTS/PROCESSES TRANSFERRED TO 35 PUBLIC/PRIVATE SECTOR UNITS SPECIAL CHEMICALS & MATERIALS - 30 ELECTRONICS/ELECTRO CHEMICAL - 20 ELECTRO - OPTICS - 13 OTHERS - 7

Fig. 24 —Technology transfer to industries

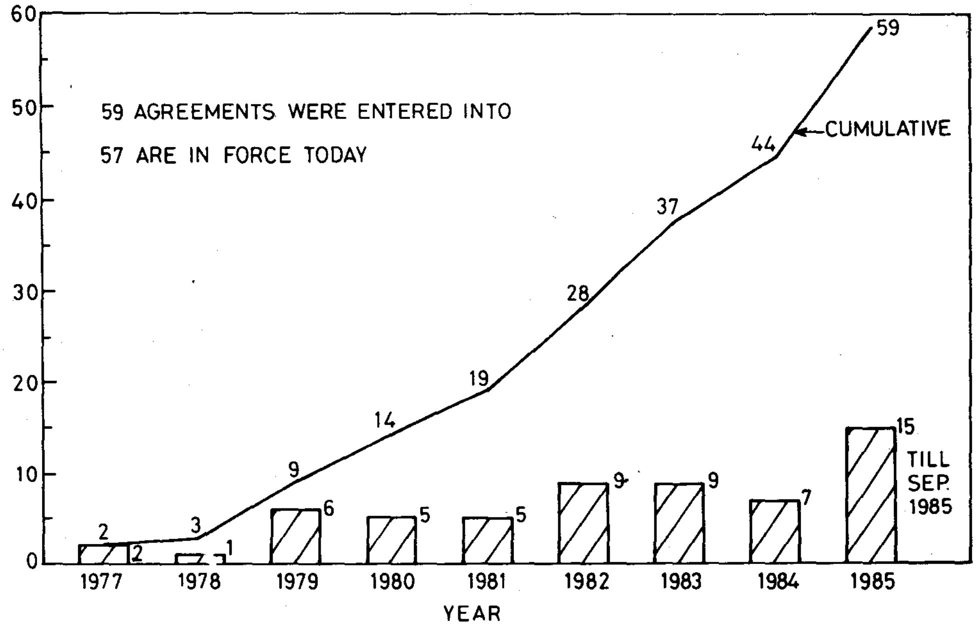


Fig. 25— Yearwise TT agreements

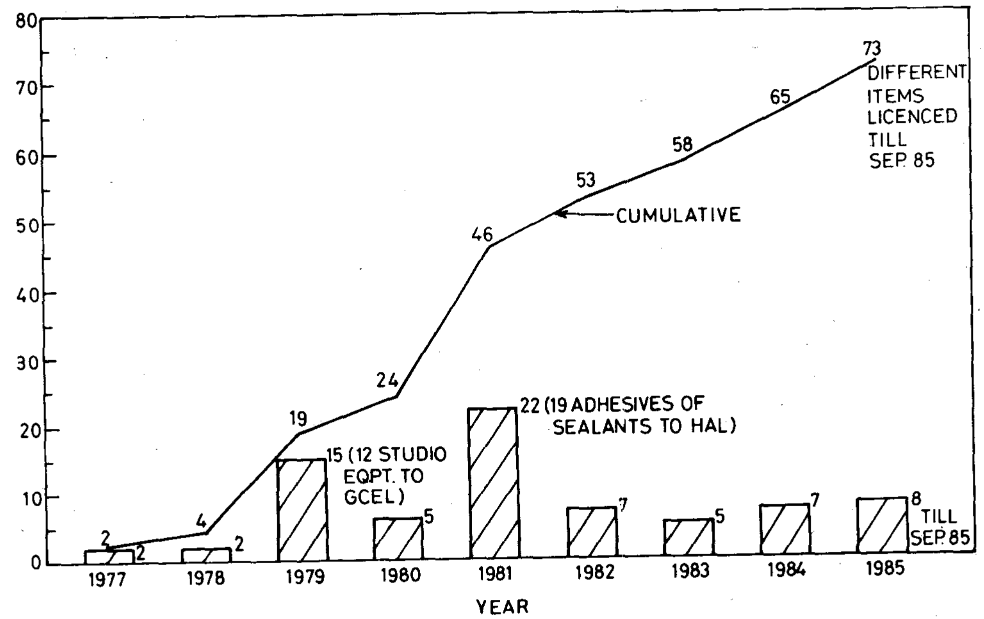


Fig. 26—New technologies licensed yearwise

ITEMS	VSSC	SAC	ISAC	NRSA	OTHERS	TOTAL
CHEMICALS	27	-	-	-	-	27
ELECTRO-OPTICS	-	1	1	2	-	4
TELECOM SYSTEMS	-	8	-	-	-	8
ELECTRO-MECHANICAL	5	-	1	-	-	6
OPTO-MECHANICAL	-	2	-	4	-	6
ELECTRONICS	2	13	-	2	-	17
MECHANICAL	1	-	-	-	1	2
SOFTWARE	2	-	-	-	-	2
ELECTRO-MECHANICAL	1	-	-	-	-	1
TOTAL	38	24	2	8	1	73
ADDITIONAL ITEMS IN PIPELINE.	20	18	12	11	8	69

Fig. 27—Technologies licensed category-wise and centre-wise

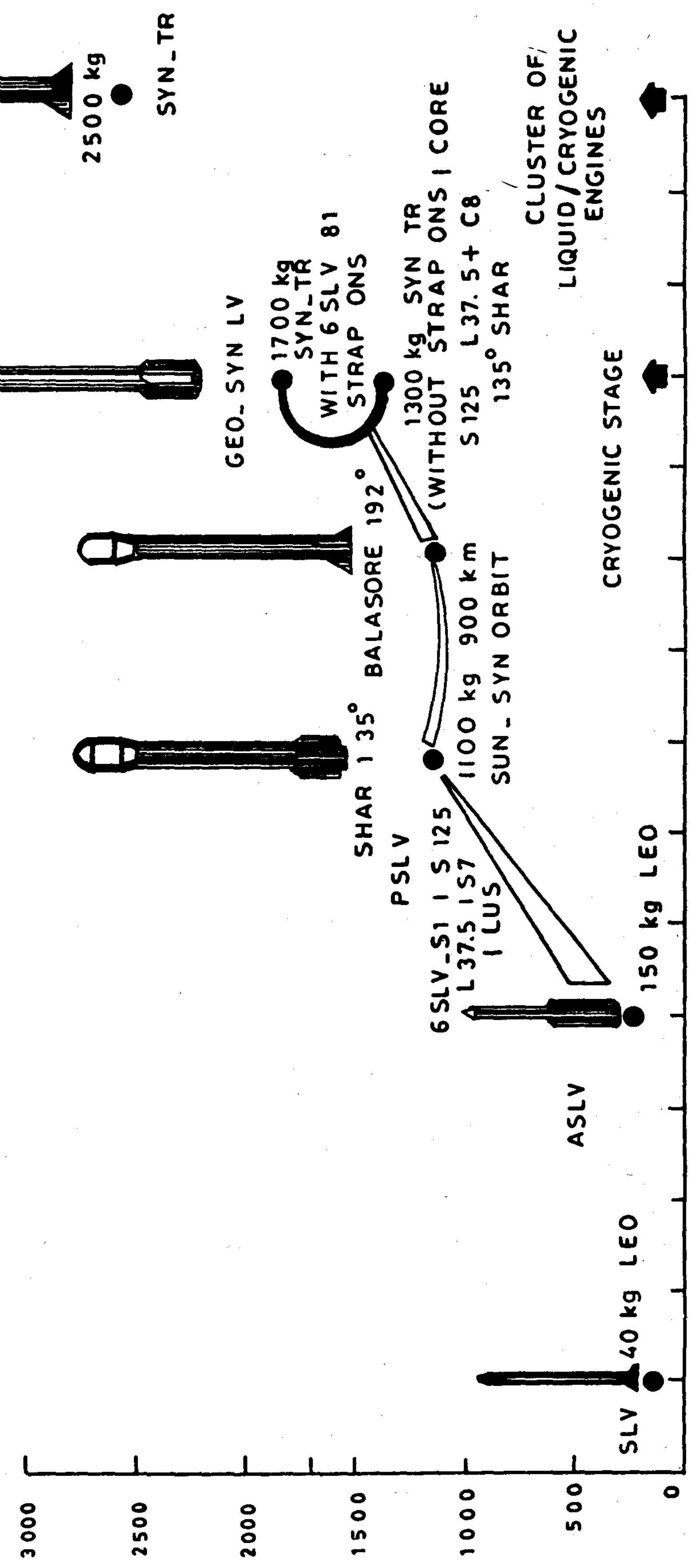


Fig. 28— Growth profiles of launch vehicles

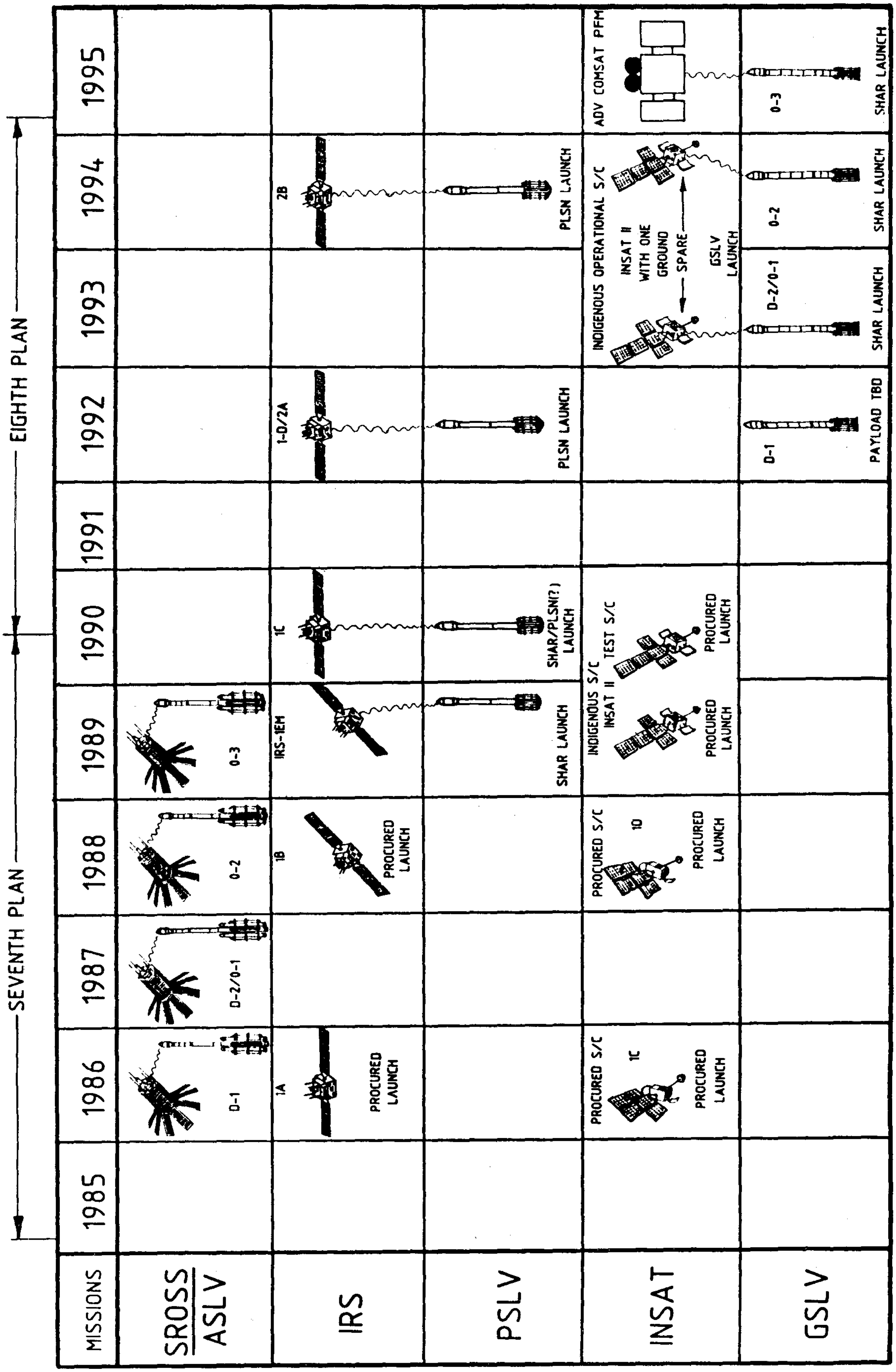


Fig. 29— Planned major Indian space missions 1985-95