April-Dec. 1998

SPACE india

INDIAN SPACE RESEARCH ORGANISATION

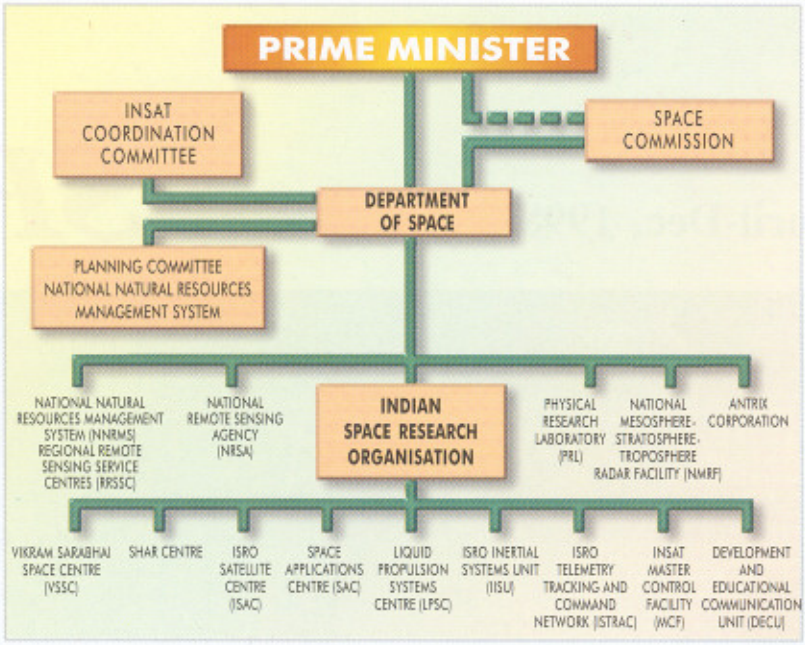
The Indian Space Programme

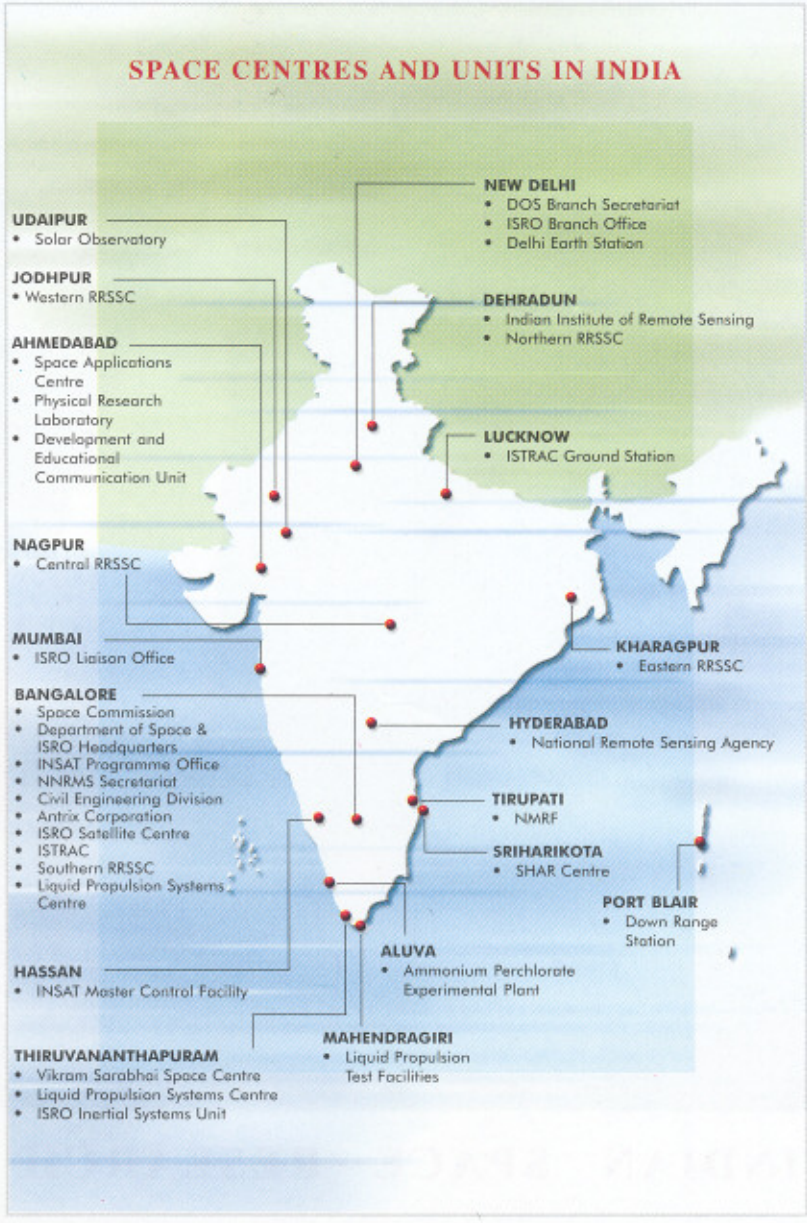
The setting up of the Thumba Equatorial Rocket launching Station (TERLS) in 1963 marked the beginning of the Indian Space Programme. The Space Commission and the Department of Space (DOS) were established by the Government of India in 1972 to promote unified development and application of space science 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 satellite and launch vehicles for providing these space services.

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

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





Front Cover:
Sounding Rocket RH-560 takes off with German Instruments

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April-December '98

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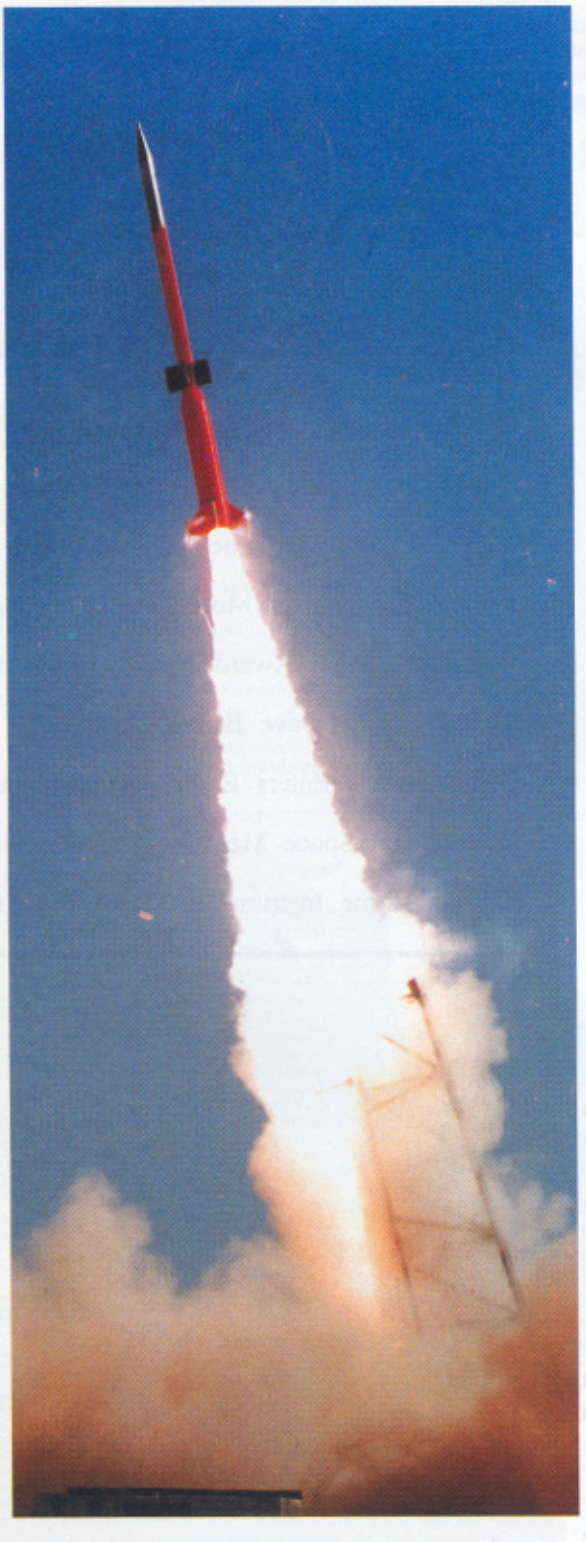
ISRO Launches German Instruments on Rohini Rockets

ISRO launched three Rohini Sounding Rockets (RH-560 Mk-II) carrying a set of five scientific instruments developed by German and other European space science laboratories. The first flight was conducted on April 19, 1998. After evaluation of this flight, subsequent flights were conducted on September 21 and 28, 1998 from ISRO's Sriharikota range 100 km north of Chennai. The instruments carried on board the three rockets were intended to study the dynamics of the equatorial ionosphere during the occurrence of Spread-F phenomena. The sounding rockets were specifically spun at 3 revolutions per second to meet the objective of the experiment. All the launches were carried out under a commercial arrangement between ISRO and the German space agency, DLR.



The five scientific payloads included Resonance Cone Payload developed by AWT, Freiburg; Radio Beacon Experiment developed by German space agency (DLR); Impedance Probe and Langmuir Probe payloads developed by University of Kiel and a Precision Magnetometer developed by Danish scientists. The Polish Space Centre, Warsaw, developed the antenna deployment systems for the radio beacon experiments. The complement of these five payloads was designed to measure electron density, electron temperature, plasma anomalies, total electron content, ion density, electron irregularities and magnetic fluctuations in the altitude region of 90 to 430 km. The measurement of various ionospheric parameters was intended for an in-depth scientific understanding of the evolution of equatorial ionospheric structure and irregularities, the physics of which has not been so far understood fully by the scientists. The measurements were also to facilitate study of radio wave propagation through the ionosphere.

ISRO sounding rockets, comprising RH-200 Mk-II, RH-300 Mk-II and RH-560 Mk-II, are used for various scientific investigations in meteorological, atmospheric and ionospheric areas. So far, more than 3000 rockets of various types and payload capabilities have been launched by ISRO for scientific investigations including those for international science campaigns like Middle Atmospheric Programme (MAP), Monsoon Experiment (MONEX) and Global Atmospheric Research Programme (GARP). Scientists from many countries including Germany, UK, USA, erstwhile USSR, France and Japan have, in the past, flown their scientific instruments from Thumba and Sriharikota. Scientific groups from several countries in Europe and Japan have shown keen interest in these sounding rockets for studying atmospheric and ionospheric phenomena over equatorial region which are of great scientific importance. The two-stage RH-560 Mk-II rocket is the largest of ISRO's Rohini sounding rockets.

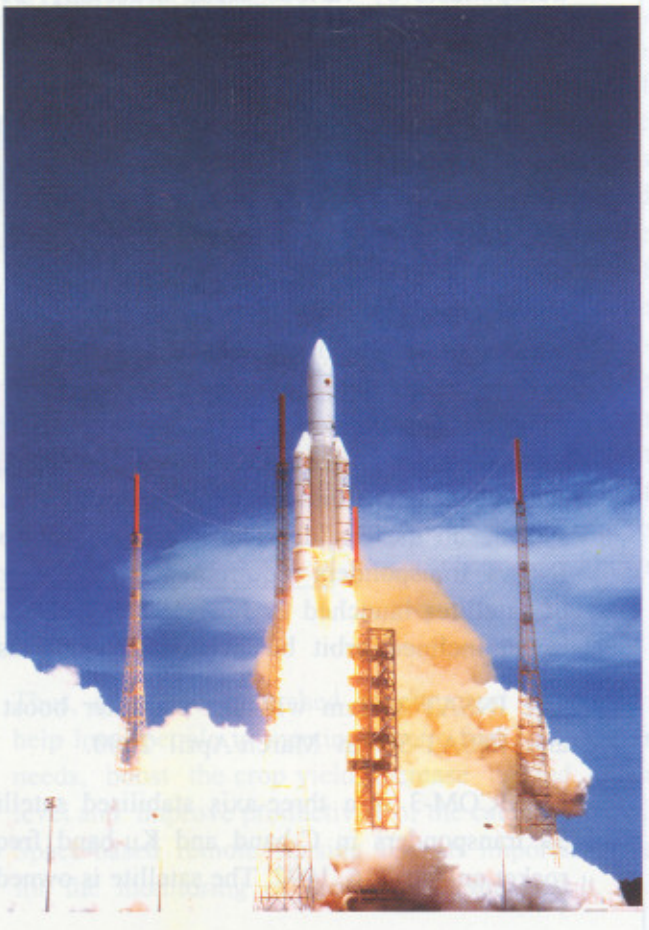
Antrix and Arianespace to Jointly Offer Launch Services

Antrix Corporation, the commercial wing of India's Department of Space and the France-based European Company, Arianespace, have signed an agreement to market ISRO's Polar Satellite Launch Vehicle, PSLV and the Ariane Launch Vehicle, ARIANE-5 of Arianespace to launch auxiliary payloads up to 100 kg. Under this agreement, signed on April 3, 1998 at Antariksh Bhavan, (the Headquarters of the Department of Space and Antrix) Bangalore, Arianespace and Antrix Corporation have formed a "Committee for Auxiliary Payload Policy Execution (CAPE)" with the objective of encouraging and enlarging the launching opportunities for small satellites. Both companies will establish a common user's manual for auxiliary payloads that will be compatible with both PSLV and Ariane-5 and thus enable users to launch their small satellites either by Ariane Structure for Auxiliary Payload (ASAP) or the Specific Auxiliary Payload Structure developed for the PSLV.

The agreement heralds the commencement of marketing of satellite launch services by India. Though, for the present, only small payloads in the weight class up to 100 kg are covered, the agreement signifies that India's capability in the launch vehicle area has been recognised by big players in this segment of the space market, especially, after the launch of PSLV; in its maiden operational flight, PSLV successfully launched the Indian remote sensing satellite, IRS-1D, in a polar orbit, clearly demonstrating its capability to place 1200 kg class satellites in to polar sun-synchronous orbit of about 800 km.

It is important to note in this context that the Antrix Corporation has already signed two agreements — one with the Satellite Technology

India's PSLV



Ariane 5 launch vehicle of Arianespace

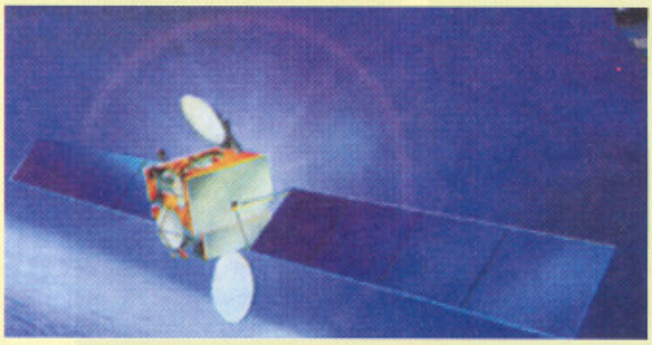
Research Centre of the Republic of Korea for launching its satellite, known as KITSAT-3, and the other with German Aerospace Centre for the launch of its satellite known as DLR-TUBSAT. Both these satellite will be flown on board the next flight of PSLV planned for launch during May 1999. These satellites will fly as piggy-backs while the Indian remote sensing satellite, IRS-P4, will be the primary payload. The 950 kg IRS-P4 is intended for ocean remote sensing applications while KITSAT-3, weighing about 110 kg, is a small experimental remote sensing and space plasma research satellite. The 45 kg DLR-TUBSAT is an experimental remote sensing satellite.

The Antrix Corporation has also signed an agreement with a Belgium Company, for the launch of its small satellite, PROBA, as a piggy back payload on board one of the forthcoming flights of PSLV some time during 2000-01. PROBA is a 100 kg satellite developed under the technology demonstration programme of European Space Agency, ESA.

Though PSLV was developed primarily to meet the launch requirement of Indian remote sensing satellites which were earlier being launched from the erstwhile USSR and Russia, India is now in a position to offer this vehicle for other space agencies on commercial basis to launch their satellites. With its present capability, PSLV will be able to carry one or two small satellites as piggy backs to the primary IRS satellites.

INSAT Capacity Augmented

The Department of Space augmented its INSAT space segment capacity by leasing six linear C-band transponders from the in-orbit satellite, 'THAICOM-3', located at 78.5° East longitude from August 15, 1998. The arrangement will help in meeting the increased requirement for transponders by various users, especially, by Department of Telecommunication (DOT) and the national television, Doordarshan.



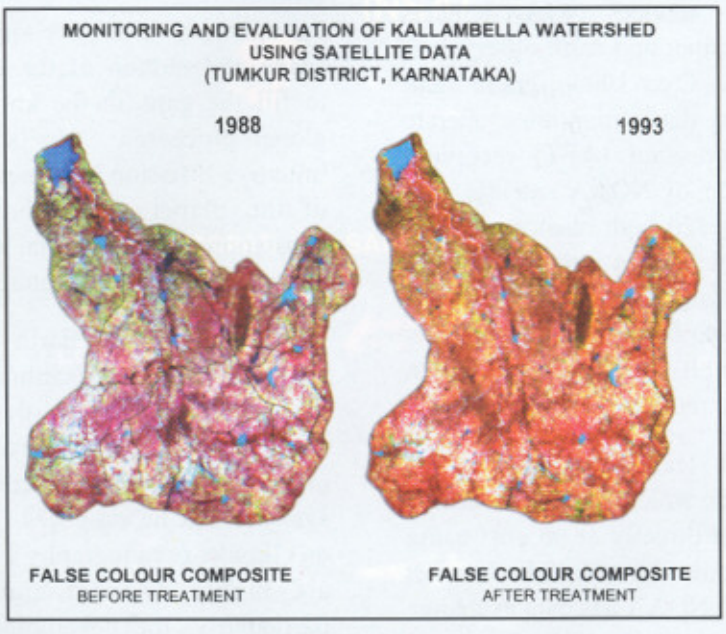
The INSAT services in India, has registered a high growth over the years, especially, in the areas of television, radio broadcasting and distribution and Very Small Aperture Terminal (V-SAT) telecom networks. A number of regional language TV services has been introduced in the Doordarshan network besides the national channels. The INSAT system capacity has been increased substantially consistent with this growth; while there were only 14 transponders in the INSAT system during the 7th Five Year Plan, the system at present has 70 transponders and today it is one of the largest domestic satellite communication systems in the world. The leasing of transponders from THAICOM-3 will help in meeting the INSAT transponders requirement after the end-of-life of INSAT-1D, the last of INSAT-1 series of satellites launched in June 1990 — INSAT-1D, which had been procured from USA, is now in an inclined orbit but it is still being used for meteorological services.

The INSAT system will get a further boost once INSAT-2E is launched in March-April 1999 and INSAT-3B in March/April 2000.

THAICOM-3 is a three-axis stabilised satellite built by Aerospatiale of France and consists of 39 transponders in C-band and Ku-band frequencies. It was launched by the European Ariane rocket on April 16, 1997. The satellite is owned by Shinawatra Satellite Public Company of Thailand.

Remote Sensing for Monitoring Watersheds

The emphasis on sustainable agriculture through optimum management of natural resources for the productivity of unit land has been a key criterian for development programme based on the watershed approach. This approach can help in restoration of ecological balance, maintenance of biological diversity, protection of catchment areas and water conservation, etc. Karnataka State realised the importance of watershed concept and has started implementing the watershed development programmes on a large scale, taking up a watershed of about 25,000 to 40,000 hectares in each district. An integrated approach has been adopted under this programme involving forestry, agriculture and horticulture sectors for development activities. The watershed development programme aims at conserving soil and moisture as well as to put the land to use in accordance with its capability. The programme also envisages increased and stabilised production of crops, forage, fruits, fuelwood and timber in rainfed areas by introduction of improved soil and moisture conservation measures, better crop and grassland management practices, animal husbandry and afforestation.



Space based remote sensing has been effectively used to monitor land resources and evaluate land cover changes and its impact on environment by comparing satellite images acquired for an area at different times. Monitoring and assessment of changes in 20 watersheds, spread over 19 districts of Karnataka has been carried out by ISRO's Regional Remote Sensing Service Centre (RRSSC) at Bangalore. Data from Indian Remote Sensing Satellites, IRS-1A and IRS-1B, covering watersheds pertaining to pre- and post-treatment periods of watersheds have been analysed using image processing techniques. The processing of satellite data, involved geometric correction with respect to Survey of India topographical maps, digitisation of watershed boundaries, and extraction of study areas and discrimination of landuse/landcover types. The classified outputs were then compared to derive changes that occurred over a period of 5 to 7 years in the watersheds.

The results have been quite encouraging. The progressive land cover transformation is clearly visible on the satellite images in the treated watersheds. Increase in area under cultivation, alternate landuse practices, increase in the area under fruit crops and tree cover, improvement in yield and productivity of agricultural crops, reclamation of wastelands, more number of waterbodies etc, are some of the changes observed in the treated watersheds. Among the 20 watersheds of different agro-climatic zones studied, improvement and progressive changes ranging from 7 percent to 27 percent of geographical areas of the watersheds have been observed within a span of 5 to 7 years.

Thus, concerted watershed development efforts can help local people in meeting their fuel and fodder needs, boost the crop yield, increase ground water level and improve productivity of the catchment area. Space-based remote sensing has an important role for the monitoring of the changes that result.

Vikram Sarabhai Award for Dr James Baker

Dr James Baker, Administrator of National Oceanographic and Atmospheric Administration (NOAA), USA, has been awarded the biennial international Vikram Sarabhai Award for 1998. The award, instituted by the Indian Space Research Organisation (ISRO) and the Committee on Space Research (COSPAR) of the International Council of Scientific Unions, consists of a gold medal and a citation. The award was announced at the COSPAR Scientific assembly at the 32nd COSPAR Scientific Assembly held at Nagoya, Japan in July 1998.

As an Administrator of NOAA, Dr James Baker has made vital contribution to developing countries by providing data for weather services. NOAA collects and broadcast recorded weather and earth observation data from NOAA satellites. Over 1000 users in more than 89 countries, including developing ones, operate Automatic Picture Transmission (APT) receiving stations for direct reception of NOAA satellite data at no cost. There are over 120 high resolution APT ground stations that enable direct access to more sophisticated data. The data collected is used for local and regional aviation, sea and lake reconnaissance, snow-cover and snow-melt observations, ocean temperature and ocean current studies.

Under Dr James Baker's leadership, NOAA has established a system under which users can access NOAA's earth system data directly at no cost using international telecommuncation systems like Internet and dial-in telephone lines. NOAA has data exchange with almost every country through International Council of Scientific Union's World Data Centre System. Also, NOAA has been providing training in NOAA Laboratories and Data Centres for foreign nationals. Dr James Baker has led NOAA programme eminently for satellite data applications and for carrying out joint projects for developing countries.

Dr James Baker has strived for international efforts that will improve the ability to predict global climate change employing, especially, space-based remote sensing. He has strongly advocated the use of satellite based instruments to gather data on earth-sun interaction, land vegetation patterns, ocean colour, temperature, the atmosphere, the ice sheets of polar regions, the shape and motion of the earth's gravity field, etc, to fill the gaps in the knowledge about the critical global processes. His strong support to the US initiative 'Mission to Planet Earth', a long range study of the planet as a whole using polar orbiting, geostationary and special orbit satellites, brings out his concern for the future of the humanity.

In his book "Planet Earth – The View from Space", Dr James Baker has examined the long range problems of security, technology transfer, data dissemination, cost, international coordination, etc, that could undermine the achievement of the global operational systems that he proposes. Dr Baker's publications on climate, oceanography and space technology issues are highly relevant and are beneficial to all, particularly, the developing countries.

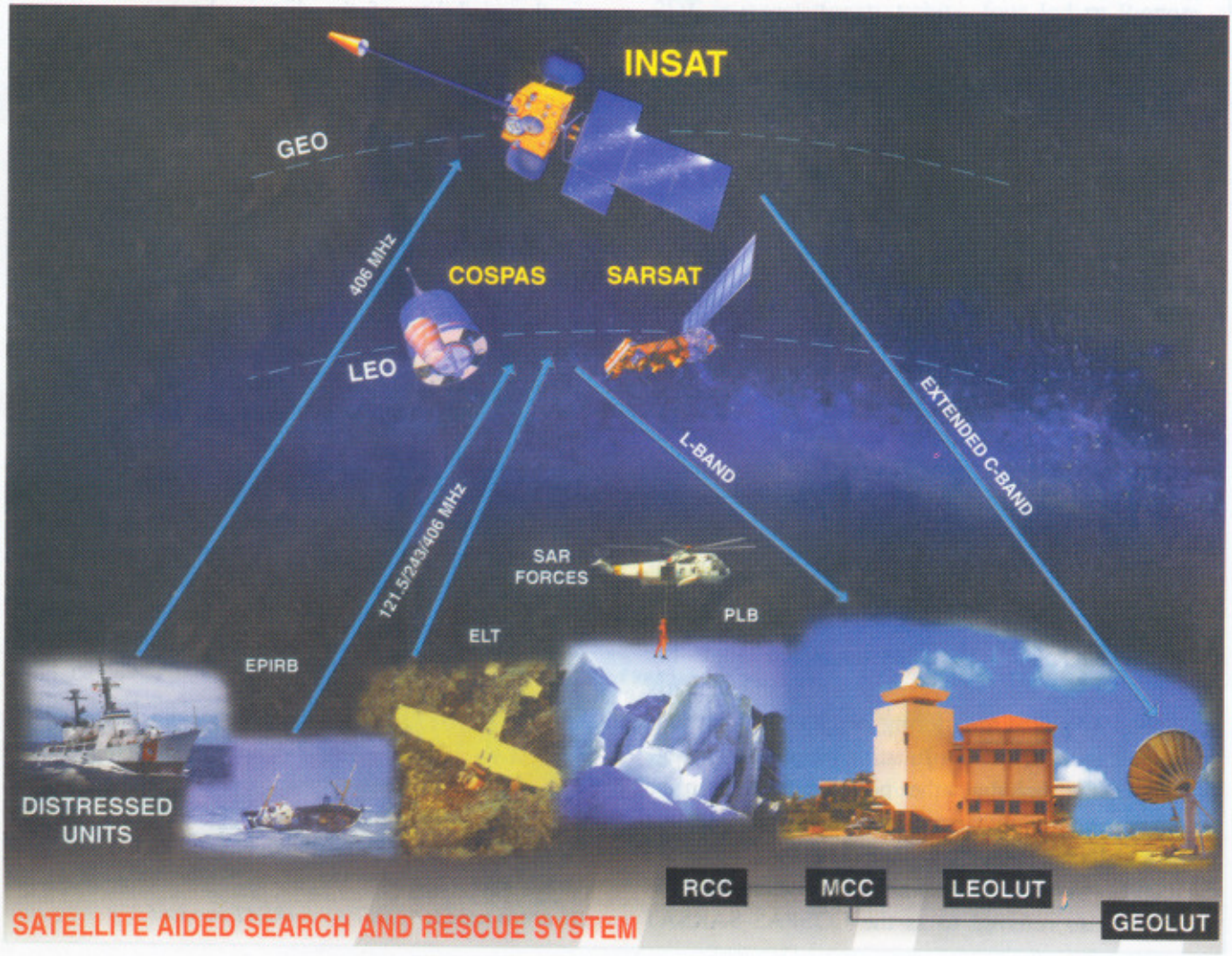
Thus, Dr James Baker, richly deserved the coveted Vikram Sarabhai Award.

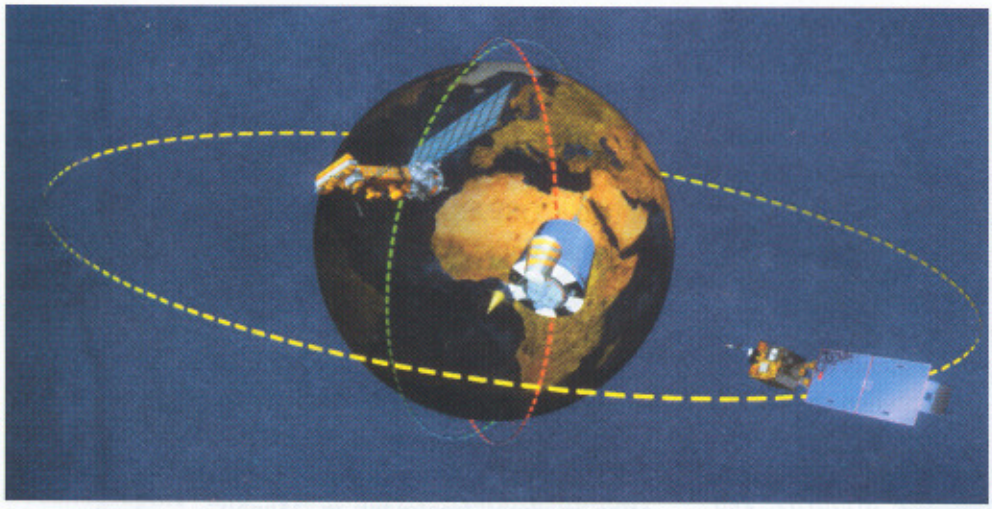
The Vikram Sarabhai Award was instituted in 1990 to recognise outstanding contributions made by individual scientists to space research in developing countries. The earlier recipients of the award are Academician Kotelnikov of Russia (1990), Prof C Y Tu of China (1992), Prof Blamont of France (1994) and Prof U R Rao of India (1996).

INSAT Helps Save British Teenager

A 16 year old British girl, who suffered from acute altitude sickness while trekking in the foothills of the Himalaya as part of the expedition organised by World Challenge Expedition, was rescued — thanks to the Satellite-Aided Search and Rescue system of INSAT. The girl, Rachael Kirkham, suddenly sufferred from high altitude pulmonary oedema when the team was at a height of 16,000 feet, 120 km north of Manali in the state of Himachal Pradesh. The team leader, realising that the condition of the girl was serious, activated the distress alert beacon and the signal was picked up by India's INSAT-2A satellite that carries Satellite Aided Search and Rescue transponder. The Indian Mission Control Centre and the Local User Terminal at Bangalore, set up by ISRO as part of the International COSPAS-SARSAT system, received the signal from INSAT-2A at 10:41 am on August 1, 1998. The signal was further confirmed through an orbiting low earth orbit satellite of the COSPAS-SARSAT system and the location was calculated based on further data received from the orbiting satellites. The Indian rescue teams were immediately alerted. The Indian Airforce rescued the girl using helicopters and admitted her to a hospital in Manali. The 12-member expedition team, comprising students aged between 16-18 years, continued their trekking while the girl fully recovered after medical treatment in Manali.

COSPAS-SARSAT is a satellite system designed to provide distress alert and location data to assist search and rescue (SAR) operations, using spacecraft and ground facilities based on signals from distress beacons operating on 406 MHz or 121.5 MHz. The distress location along with related information are forwarded by the concerned COSPAS-SARSAT Mission Control





GEO Satellites compliement the LEO satellite for Search & Rescue by providing quick distress alert.

Centre (MCC) to appropriate national search and rescue authorities. Its objective is to support all organisations in the world with responsibility for search and rescue (SAR) operations, whether at sea, in the air, or on land.

The satellite system was initially developed under a Memorandum of Understanding among Agencies of the former USSR, USA, Canada and France, signed in 1979. The system was declared operational in 1985. In January 1992, the government of Russia assumed responsibility for the obligations of the former Soviet Union. A number of States, Non-Parties to the agreement, have also associated themselves with the programme and participate in the operation and the management of the system.

The use of satellites to detect and locate special-purpose radio-beacons, either manually activated or automatically activated by an aircraft or maritime distress situation, reduces the time required to alert the appropriate authorities and for final location of the distress site by the rescue team. The International Maritime Organisation (IMO) and the International Civil Aviation Organisation (ICAO) recommend that ships and aircraft carry Emergency Position Indicating Radio Beacon (EPIRBs) and Emergency Locator Transmitters (ELTs) respectively.

COSPAS-SARSAT has demonstrated that the detection and location of distress signals can be greatly facilitated by global monitoring based on low-altitude spacecraft in near-polar orbits. Complete coverage of the earth, including the polar regions, can be achieved using simple emergency beacons operating on 406 MHz to signal a distress. The COSPAS-SARSAT system of satellites in Low Earth orbit (LEO) is also referred to as the COSPAS-SARSAT LEOSAR System.

Polar orbiting satellites used in the COSPAS-SARSAT LEOSAR System can provide a global, but non-continuous coverage, for the detection and the positioning of distress beacons, using a Doppler location technique. However, the non continuous coverage introduces delays in the alerting process since the user in distress must "wait" for a satellite pass in the visibility of the distress beacon.

Search and Rescue payloads on Geostationary satellites like INSATs can provide continuous coverage over one third of the globe and help immediate detection of distress alerts with the use of new beacons having position data along with beacon identity.

Since 1996 COSPAS-SARSAT participants have been experimenting with 406 MHz beacon payloads on satellites in the Geostationary Orbit, namely, INSAT-2A and GOES-E&W satellites of USA, together with the associated ground stations to detect the transmission of 406 MHz beacons world wide. These experiments have demonstrated and shown the possibility of almost immediate detection of alerts

Beacons used for COSPAS-SARSAT services

at 406 MHz, providing the identity of the transmitting beacon and encoded datas such as the beacon position derived from a global satellite navigation system. This development is referred to as the 406 MHz GEOSAR Systems.

The GEOSAR systems nevertheless support the existing beacons also, providing immediate distress alert detection with beacon identity. The position information is supplemented later by LEOSAR using Doppler data. Thus LEOSAR & GEOSAR complement each other and enhance the system performance capability for saving lives in distress over sea, air and land.

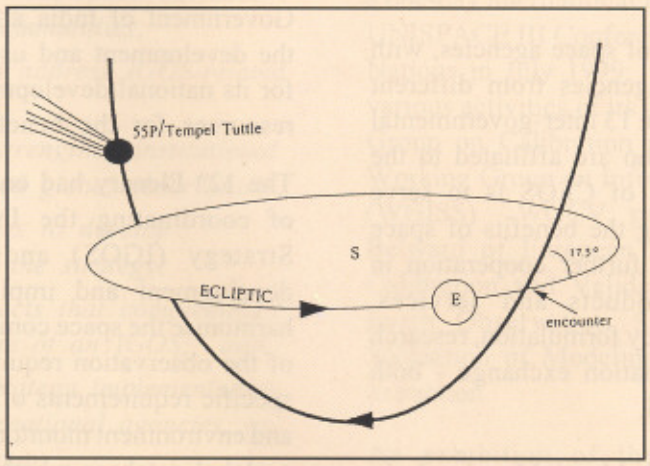
India is playing an active role in the international satellite aided search and rescue programme. It has not only set up the Indian mission control centre at Bangalore and two LUTs, one at Bangalore and the other at Lucknow, but also incorporated search and rescue transponders on board its INSAT system. This system has helped save several lives since it was set up on October 1, 1989 and the recent rescue of the British girl is yet another example of how a space-based system can help those in distress in remote and inaccessible locations.

Comet Debris Enters Earth's Atmosphere

— ISRO Satellites Unaffected

Even as the Leonid meteoroids, associated with Comet 55P/Tempel-Tuttle, entered the earth's atmosphere during the period November 14-20, 1998, ISRO had prepared well to minimise any possible damage that would have been caused to its satellites, had the debries hit them. None of the ISRO satellites was affected by the meteoroid shower. The meteoroids storm peaked around 02.10 am on the morning of November 18, and the Zenithal Hourly Rate could have touched about 1,50,000 particles per hour.

The main risk from the meteoroids storm could have been physical, mechanical and electrical damages to the satellite resulting in direct mechanical cratering, plasma or electro-static discharges. ISRO closely monitored the health of all its satellites from the Spacecraft Control Centres (ISTRAC at Bangalore for low earth orbit satellites and Master Control Facility at Hassan for geostationary satellites) to detect any electrical anomalies during the period. The designers of various satellite subsystems were present at these spacecraft control centres to guide any corrective operations, if necessary.



Earth-Leonid encounter.

ISRO has five INSAT satellites – INSAT-1D, INSAT-2A, INSAT-2B, INSAT-2C and INSAT-2DT in geostationary orbit, four Indian Remote Sensing Satellites (IRS-1B, IRS-1C, IRS-1D and IRS-P3) in polar sun-synchronous orbit and a scientific satellite – SROSS-C2 in near-earth orbit. Some of the precautions taken included: to orient the solar panels of the satellites in such a way that they presented minimum surface area to the approaching meteoroids debris, suspension of satellite operations like that of Panchromatic camera steering on board IRS-1C and IRS-1D and operation of high voltage instruments like X-ray payload on IRS-P3 and Gamma-ray instruments on board SROSS-C2 satellite. The body movement rates of INSAT were also closely monitored using the gyros to detect any meteoroid hits.

Though the probability of the satellites getting hit by the meteoroid debris was small, ISRO took all necessary precautions to minimise the impact of the meteoroids, if any. The event passed off without any incident of damage.

International Space Meet Held in Bangalore

ISRO hosted the 12th Plenary Meeting of the Committee on Earth Observation Satellites (CEOS) at Bangalore during November 10-12, 1998. The meet was inaugurated by Dr Murali Manohar Joshi, Minister of Human Resources Development and Science and Technology, Government of India, on November 10, 1998. Dr K Kasturirangan, Chairman, ISRO who had taken over the Chairmanship of CEOS during the 11th Plenary Meeting at Toulouse, France, in November 1997, chaired the Bangalore Plenary. The meeting was attended by 74 representatives from 38 space and user agencies.

CEOS is a multilateral forum of space agencies, with a membership of 24 space agencies from different countries in the world. There are 13 inter-governmental user agencies/UN agencies who are affiliated to the CEOS. The major objective of CEOS is to serve as a forum towards optimising the benefits of space borne earth observations and further cooperation in mission planning, data products and services, applications development, policy formulation, research for global change and information exchange - both at technical and policy level.

Inaugurating the 12th Plenary, Dr Murali Manohar Joshi said that observation of earth from space has become an important endeavour of human kind in this age. The data from earth observation satellites are now widely used in several developmental activities like agriculture, forestry, water resources, urban planning, disaster monitoring and mineral exploration. He said that satellite remote sensing has immense relevance for studying the problems of global significance such as global warming and long term changes in the global climate. In addition, observation from satellites has given us tremendous awareness on the effect of human actions on earth's environment. He appreciated the work of CEOS in increasing the benefits of space borne earth observation by promoting international coordination and cooperation. Dr Murali Manohar Joshi stressed the importance of Integrated Global Observing Strategy that is being initiated by CEOS towards harmonisation of space based observations with in-situ and ground observations for key application areas. He further added that the Government of India attached great significance for the development and use of satellite remote sensing for its national development and for sharing its space resources for the benefit of global community.

The 12th Plenary had on its agenda, important issues of coordinating the Integrated Global Observing Strategy (IGOS) and planning for its further development and implementation. IGOS aims to harmonise the space component and in-situ component of the observation requirements towards meeting the specific requirements of users for global applications and environment monitoring. It also aims at developing a global database which will be used for monitoring the changes in the earth's environment. IGOS, that was earlier being coordinated by CEOS, is now being developed under a partnership amongst sponsors of the Global Observing Systems (ICSU, FAO, UNEP, UNESCO-IOC, WMO); Global (Climate/Ocean/ Terrestrial) Observing Systems (GCOS, GOOS, GTOS) Programme Offices; Committee on Earth Observation Satellites (CEOS; comprising member

Dr Murli Manohar Joshi inaugurating the CEOS meet by lighting the traditional Indian lamp

space agencies contributing to an IGOS); International Group of Funding Agencies (IGFA); International Geosphere - Biosphere Programme (IGBP) Programme Office and World Climate Research Programme (WCRP) Programme Office. The Partnership which was formalised on June 6, 1998 at Paris, aims to:

- *exchange information on the Partners' relevant activities;*
- *promote dialogue between the space agencies and in-situ observation communities;*
- *identify gaps and seek to address IGOS-related user requirements;*
- *identify requirements to strengthen institutional capacity to make integrated global observations;*
- *carry out specific activities to develop individual components of the strategy;*
- *identify and suggest projects that complement and demonstrate the value of an IGOS; and,*
- *promote all aspects of strategy implementation, among national and international agencies, as well as different user groups.*

The 12th Plenary formally endorsed the Partnership and prepared its own strategy for the development of the space component strategy in support of IGOS. Similarly, global (climate/ocean/terrestrial) observing systems would address the in-situ component strategy in support of CEOS. The two strategies, when integrated, is expected to provide, in an evolutionary manner, assured commitments of observation, leading to establishment of global databases of essential parameters required by users.

The Plenary also identified a Strategy Implementation Team (SIT), under the Chairmanship of Dr Robert Winokur of NOAA, for developing the space component strategy. The SIT would work out the strategy for evaluating the IGOS projects and also guide them for development under the framework of the IGOS Partnership.

The Bangalore Plenary also reviewed the status of the 6 proto-type projects identified for definition of the IGOS concepts - Long term continuity of Ozone Measurements; Upper Air Measurements; Global Ocean Data Assimilation Experiment (GODAE); Global Observation of Forest Cover (GOFC); Long term ocean biology measurements and Disaster Management Support. Analysis of specific observation requirement have been conducted by these projects and CEOS would evaluate the space-based strategies required to meet those requirements. It is hoped that CEOS agencies would assimilate these requirements into their mission plans and thus ensure a committed observation system for the requirements. This would be an important element of the space component strategy. The CEOS Plenary also decided to organise, jointly with the other members of the IGOS partnership, a one-day international IGOS forum at the forthcoming UNISPACE III Conference being organised by United Nations in July 1999. The CEOS Plenary reviewed various activities of its two working groups - Working Group on Calibration and Validation (WGCV) and Working Group on Information Systems and Services (WGISS). WGCV, presently Chaired by Mr.Alan Belward of European Commission, coordinates the Calibration and Validation activities - both for the Earth Observation Sensor Calibration and the Validation of Modeling and Geophysical Parameter extraction.

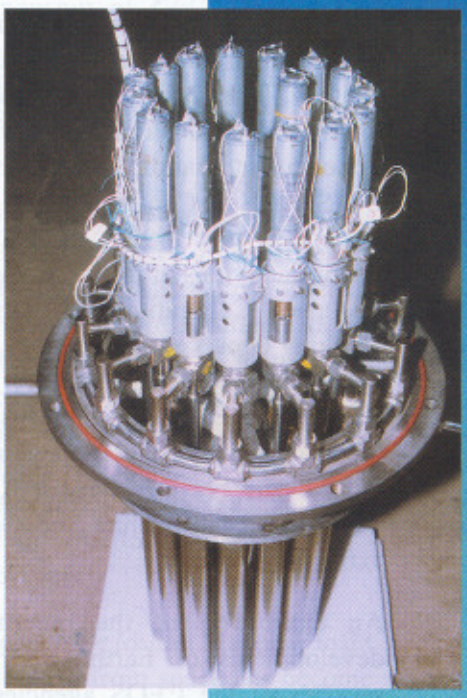
An exhibition of the recent achievements and developments of Earth Observation products and services of the CEOS agencies was also organised to coincide with the COES Plenary.

The CEOS 12th Plenary concluded with Dr Tillman Mohr, Director, EUMETSAT taking over the Chair of CEOS from ISRO. For the year 2000, INPE, the Brazilian Space Agency will Chair the CEOS and in 2001, NASDA would be Chairing CEOS.

Balloon Payloads Flown for Atmospheric Studies

A Cryogenic Sampler Payload was successfully flown from National Scientific Balloon Facility of Tata Institute of Fundamental Research (TIFR) at Hyderabad at 4 am on April 18, 1998 to measure several trace gases, such as chloro-floro-carbons, halons as well as the recently introduced substitutes for Chloro-Floro-Carbons (CFC). The 380 kg Cryogenic Sampler was developed by ISRO. The flight formed an important part of ISRO Geosphere-Biosphere-Programme and was intended to study the depletion of earth's ozone layer in the stratosphere and also the green house warming substances in the tropospheric region. The cryogenic sampler comprised 16 cryogenic-probes and was lifted by the 1,50,000 cubic metre balloon to an altitude of 37 km. The cryogenic probes collected ambient samples at various altitudes during both the ascent and descent phase of the balloon flight.

India is among the few countries in the world to develop and successfully use sophisticated instruments like cryogenic sampler that enables measurement of most of the ozone depleting substances that are covered under Montreal Protocol to which India is also a signatory. Though India's contribution to ozone depleting substances that are released into the atmosphere is less than 0.1 percent, the atmospheric dynamics are such that the abundance of these substances in the tropical region is an index of global



Balloon carrying the cryogenic sampler payload (Inset)

Keeping Watch on Earth's Atmosphere

The earth's atmosphere is unique. No other planet in our solar system has an oxygen rich atmosphere and oxygen is vital to the sustenance and support of life on earth as we know of it today. Ozone (O_3) is a special feature of the earth's atmosphere. It absorbs solar ultraviolet (UV) radiations in the 2000 to 3000A wavelength region (One Angstrom is one tenth of a milli-micron). This includes the so called UVB radiation (2500A to 2800A) which is harmful to plant and animal life since it attacks proteins and the DNA molecule which are essential ingredients of life forms. This radiation is completely absorbed by ozone in the earth's atmosphere. In the absence of ozone some of the radiation would reach the earth's surface and affect adversely all forms of plant and animal life including humans.

There is growing concern, in recent years, that the protective ozone layer is endangered by several activities of the present mankind. Simple day-to-day activities such as use of refrigerators and spray-cans, fire extinguishers, etc, and high-technology industries and supersonic aircraft are releasing gases into the atmosphere which, when transported to high altitudes (exceeding 20 km), give rise to ozone destroying chemicals like chlorine (Cl), bromine (Br) and nitric-oxide (NO) when they are attacked by solar UV radiation.

A typical reaction cycle is:

$$O_3 + Cl \rightarrow ClO + O_2$$
$$ClO + O \rightarrow Cl + O_2$$

Thus, in the net reaction, Cl is recovered intact at the end of the cycle. Br and NO also play similar role. In a typical case, a single molecule (Cl, Br or NO) can go through the reaction cycle many times and destroy several thousands of ozone molecules before it is removed from the atmosphere. Further, most of the source gases for these ozone destroying radicals are chemically inert and have long life. Hence, there is a growing concern that global atmospheric ozone will slowly and steadily decline causing increased UV incidence at ground with probable adverse impacts on the biosphere. Evidence for this already exists in the south polar regions where ozone decreases by almost fifty percent for a few weeks to a month during September-October (Antarctic Ozone Hole). Ozone decreases in the Arctic springs (February-March) are much less, nevertheless, a significant 5 to 6 percent. At middle and lower latitudes also, there is growing evidence of ozone decreases even though the magnitudes are smaller. While there are many source gases which can contribute to ozone destruction, the major contributors are a family of chlorine containing compounds called Chloro-Fluro-Carbons (CFC) and the Halons (which contain bromine).

Table 1: Atmospheric abundances, lifetimes and ozone depleting potentials of CFCs and related gases.

Trace Gas	Concen-tration	Lifetime	Ozone Depleting Potential
CFCs and Halons:			
CFC 11	260 ppt	55 yrs.	1.0
CFC 12	530 ppt	116 yrs.	0.9
CFC 113	80 ppt	110 yrs.	0.9
CFC 114	20 ppt	220 yrs.	0.85
CFC 115	5 ppt	550 yrs.	0.5
Halon 1301	2.5 ppt	60 yrs.	12
Halon 1211	4 ppt	20 yrs.	4
Halon 2402	0.5 ppt	2 yrs.	6
CH_3Br	10 ppt	1.2 yrs.	1.1
Substitute Gases:			
HCFC 22	120 ppt	16 yrs.	0.4
HCFC 141	5 ppt	10 yrs.	0.1
HCFC 142	7 ppt	22 yrs.	0.05
HFC 123	10 ppt	--	--
HFC 134	3 ppt	--	--

Note: 1. ppt = parts per trillion (1 in 10^{12})
2. Substitute gases have very low ozone depleting potential.

Recognising the seriousness of the ozone depletion problem, scientists world over have evolved an action plan to monitor the ozone layer and the growing abundances of ozone destroying gases. Further, there is a concerted effort to regulate the production of

the ozone destroying chemicals (Montreal Protocol 1987) and develop ozone friendly alternatives.

In India, under the ISRO's Geosphere-Biosphere Programme, a sophisticated instrument, the balloon-borne cryogenic air sampler payload, has been developed to measure the vertical distribution of the entire family of trace gases that contribute to the ozone depletion. These instruments can also be used for a number of other studies in atmospheric chemistry. The cryogenic sampler consists of 16 cryogenic-probes in the form of tubes, each with about 400 milli-litre capacity. The tubes are evacuated and immersed in liquid neon (at 270 U). Each tube is filled with a valve controlled by a motor with the help of a cryogenic control unit. The entire instrument, along with the control, tracking and telemetry units, weighing about 200 kg is lifted up by a 1,50,000 cubic metre balloon. The balloon is flown from the National Balloon Facility at Hyderabad. They can reach an altitude of 35 km or more and air samples are collected at different pre-determined altitudes by commanding from ground. Two balloon flights were conducted with the instrument — the first on April 16, 1994 and the second on April 18, 1998.

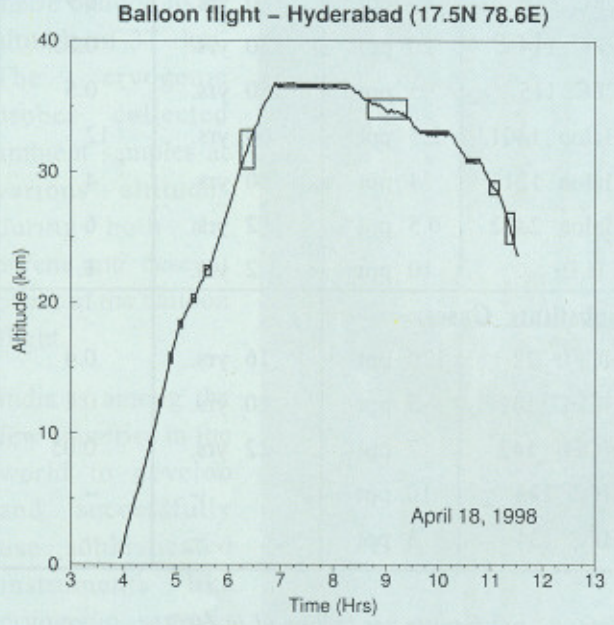


Figure shows the balloon trajectory and the air sample collection sequence for the April 1998 balloon flight. The sample collection covers an altitude range of 6km to 37km.

The cryogenic sampler is recovered after the balloon flight and the air samples are analysed at Physical Research Laboratory, Ahmedabad, using gas-chromatograph and gas spectrometric technique. In principle, the technique is capable of measuring a large number of trace gases whose abundances are as low as a few parts per billion to a few parts per trillion by volume.

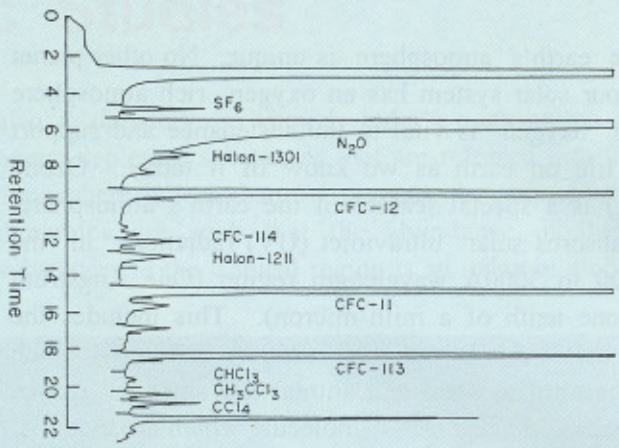
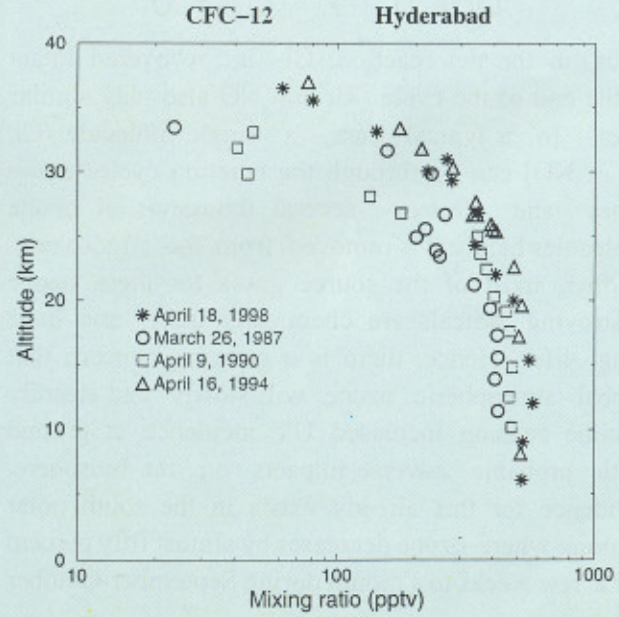
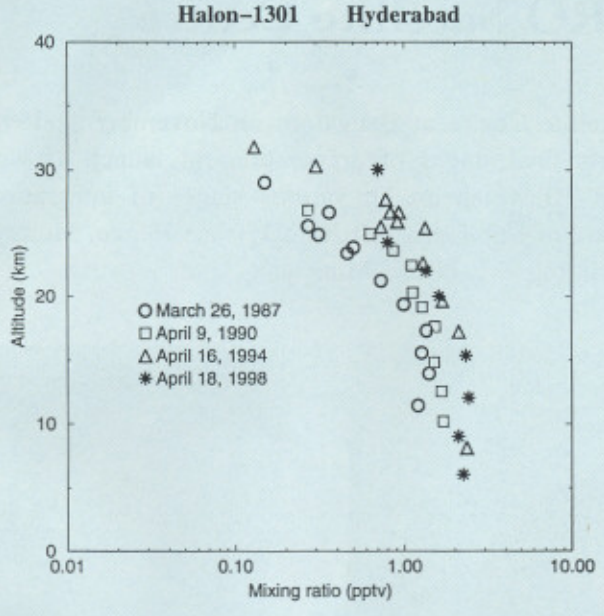


Figure shows a typical gas chromatogram obtained during the analyses of various halocarbons using GC-ECD. The retension times are shown in minutes.

The measurements have provided, for the first time, a complete set of trace gas profiles in the tropics including methane, CFC11, CFC12, the HCFCS, halons 1211 and 1301, methyl bromide, sulphur hexa-fluoride and nitrous oxide. These have been used to estimate the growth rates of the source gases in the atmosphere and to evaluate their role in ozone depletion. It has been found that while the abundances of CFCs, namely, CFC11 and CFC12 are growing in the atmosphere, their growth rates have decreased from 4 and 6 percent per year respectively for CFC11 and CFC12 in the 1987-90 period to a value of 1.6 percent per year now for



both the gases. Similarly, the growth rate of the halons 1211 and 1301 are also decreasing now. This is commensurate with the decrease in production of these compounds in compliance with the Montreal Protocol (1987) and its amendments. However, as some of these compounds are being phased out, substitutes are being introduced to meet the industrial



requirements. While these substitutes are believed to be ozone-friendly they have other impacts in the atmosphere like role of HCFC22 in greenhouse warming. Methyl bromide which has been extensively used in the agricultural sector as a fumugent has been found to be a major source of bromine in the stratosphere (bromine is a much more effective ozone destroyer than chlorine).

The full set of trace gas profiles obtained from the Hyderabad balloon flights have been used to estimate the total chlorine abundance in the stratosphere. Stratospheric chlorine has increased from a value of 3.1 ppb (parts per billion by volume) in 1987 to 3.35 ppb in 1990, a growth rate of 2.6 percent per year and a value of 3.64 ppb in 1994, a growth rate of 2.15 percent per year. It is expected that the growth rate would reduce further and the chlorine will stabilise in the stratosphere around 2000 AD before it starts declining. However, the decline would be slow since the gases already released into the atmosphere will take tens to hundreds of years to decay.

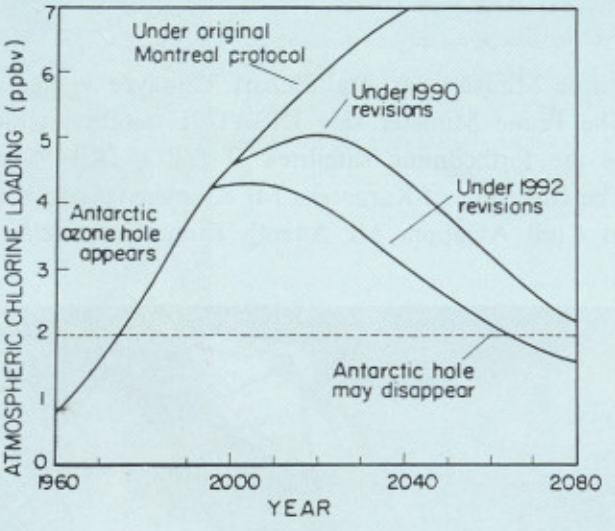


Figure shows evolution of ozone destroying chlorine in the atmosphere.

The global ozone depletion started in the 70s and the Antarctic Ozone Hole appeared in 1975 when stratospheric chlorine exceeded a value of 2 ppb. It is believed that stratosphere ozone should recover to such a value if ozone depletion were to stop and the ozone hole were to disappear. This would take at least another 50 years, that too, if the provision of the Montreal Protocol and its amendments are strictly adhered to by both developed and developing countries.

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ozone destructive potential. Hence the importance of these measurements. The cryogenic probes that operate at minus 248 degree C employ liquid neon as cryogenic fluid. After recovering the payload, the high vacuum (10-5 milli bar) probes bring back samples at pressures of over 200 bar and, in some instances, even at up to 600 bar.

The Geosphere-Biosphere-Programme is one of the leading international programmes in the world which is contributing to the measurement of a number of ozone depleting substances including their vertical profiles. The ISRO's experiment was not only to study the growth rates of ozone depleting substances but also the tropospheric abundance of CFC substitutes about which scientists are concerned on their green house warming effect.

Prime Minister Visits ISRO Satellite Centre

Prime Minister Mr Atal Behari Vajpayee visited ISRO Satellite Centre at Bangalore on November 1, 1998. The Prime Minister saw INSAT-2E satellite which is in its final stages of preparation for launch as well as the forthcoming satellites of ISRO, IRS-P4 and INSAT-3B which are in various stages of integration. The Governor of Karnataka Mr Khurshed Alam Khan, Minister of Commerce Mr Ramakrishna Hegde, Minister of Civil Aviation, Mr Ananth Kumar were also present during the Prime Minister's visit.

Prime Minister Mr Atal Behari Vajpayee (sixth from left) posing for photograph in front of INSAT-2E at the Integration Laboratory of ISAC. Also seen are (from left to right) Dr P S Goel, Director, ISRO Satellite Centre, (fourth), Dr K Kasturirangan, Chairman, ISRO, (fifth), Mr Ramakrishna Hegde, (Seventh) and Mr Khurshed Alam Khan (eighth).

IRS-1D Completes One Year in Orbit

The Indian Remote Sensing (IRS) satellite, IRS-1D, completed one year of operation in orbit on September 29, 1998. The satellite, launched by India's Polar Satellite Launch Vehicle, PSLV-C1, carries three instruments: a Panchromatic camera (PAN) with a spatial resolution of 5.8m; a Linear Imaging Self Scanner (LISS-III) operating in four spectral bands with sptial resolution of 23.5m in visible and near infrared bands and 70.5m in short wave infrared band and; a Wide Field Sensor (WiFS) with a ground resolution of 188m. Besides National Remote Sensing Agency, Hyderabad, several ground stations around the world receive data from IRS satellites.

This imagery processed by Space Imaging, USA, from the multi-spectral LISS-III sensor, of IRS, shows a cuprite mine. Visible are detailed mining activities and geological features, some of which can be differentiated from the vegetation covering them. Crop irrigation patterns show in natural green. This imagery is useful for mining companies for mapping out new sites or determining the best location for transportation or pipeline corridors.

Imagery Courtesy: Space Imaging, USA