Indian Society of Remote Sensing
Ahmedabad Chapter

NEWS LETTER

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Dear Members,

Under theme subject of 'Remote Sensing in 1990s' every effort has been made to build up a skeletal yet up-to-date scenario, but the extensive nature of the subject prevents us from claiming it either to be exhaustive or thorough. You may kindly send your inputs or corrections/additions to this theme.

Survey on remote Sensing and space has been compiled from many sources. This includes a number of Newsletters (CSIRO, EOSAT, ISRO Newsletter like ISREL, Space Spectrum) regularly provided by Dr. George Joseph (Chairman ISRA-AC and Associate Director SAC) and publications like Space News, American Aerospace, Remote Sensing Society Newsletter, ITC Journal, Remote Sensing in Canada, ESA Journal etc. Certain sources were pointed out by Dr. V K Srivastava, Shri J S Parihar and Shri K M Mathur.

Your inputs will be awaited also regarding role of remote sensing in Agriculture which will be theme subject for the next issue of Newsletter.

- Editor

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GENERAL OUTLOOK

For remote sensing, if 1970s were the era of probing and awakening, 1980s an era of experimentation and consolidation, then 1990s will be one of rapid technological advancement, operationalisation and unprecedented commercialisation. From a marginal existence of a fledgeling branch of technology, RS in 1990s will move to a stature of indispensibility. Going purely by numbers, there were only about half-a-dozen RS satellites at the end of 80s. The figure will jump two-fold or more by the end of 1990s. If one adds the level of sophistication likely to be incorporated in the RS satellites of 1990s, the net capability would have enhanced many more times. The picture is simply rosy.

Many of the satellites in this decade will continue to be designed to serve the cause of national development. But market mechanism will start riding this basic consideration, even for uninitiated, developing countries. Of course, on the other end of scale, will lie the nations or private firms whose sole purpose will be commercial. Most of these satellites will be tuned to serve the cause of local, regional or national level applications. On global front, an exciting new development of 1990s (end even beyond) will be spearheaded by United States of America under its Global Change Research Programme. It includes Earth Observation System (EOS) consisting of a series of platforms and probes to be launched in 1990s. The US program under the aegis of international effort called 'Mission to Planet Earth' will truly measure the pulse of earth by monitoring the thin veneer of life - supporting shell called biosphere.

COMMERCIAL OUTLOOK :

The World View

Remote Sensing of erath resources is likely to turn out a whopping $ 10 bn world business by the end of decade. Current world-wide sales of RS data have already touched $ 800 m and it is likely to reach an estimated high of $ 2.4 bn by 1994. Expected annual growth rate of RS business is forecast to be anywhere between 20-30 per cent. Conservative estimates in past pegged the potential RS market at $ 2 bn.

An important pointer to future of RS business, particularly in developed countries is the growing tendency towards increasing privatisation. So one discerns a range of priorities in programs of different countries - ranging from a Australian model of pragmatic mix of roles for private sector, government organisations and academic institutions to an Uncle Sam style lassaiz-faire of free enterprise in not only various sectors of RS endeavours but in space related activities in general - with NASA and Government acting as catalytic agents.

Secotorwise trends show a steady growth for companies engaged in enhancement and analysis of satellite data. Steep growth is predicted for GIS sector and value-added products and equipments - thanks largely to declining computer prices. Private firms in western countries are currently engaged in both supply of equipment as well as services. Sale of RS data to private firms and local agencies is increasing. EOSAT and SPOT image forecasts for 1990s show that while sales to federal governments accounted for more than 80 percent of total data sales during late eighties, it will come to down to barely 35 per cent by mid 1990s.

National Scenario

The country has a comprehensive application-driven remote sensing program encompassing development of sensor payloads, satellites, launch vehicles, data reception and dissemination facilities. Department of Space, the focal point of these developments, is also engaged in development of support technologies like equipment for ground investigation, visual interpretation and digital image processing and softwares for image processing and GIS. A fledgling remote sensing industry in the country has emerged due to efficient transfer of these technologies and their mass production to cater to both the in-house as well as the user needs. Apart from steady growth of the industries based on support technologies, 1990s is also likely to see the emergence of applications-based enterprises - largely due to vigorous promotion drive from DOS. Regarding RS satellites, the country will soon launch IRS-1B which will be similar to its predecessor IRS-1A. A quantum jump in operational capabilities will be achieved with the launch of IRS-1C which will feature a package of three sensors and vastly improved resolutions - bringing the country at par with the advanced nations of the world. A similar follow-on IRS-1D and satellite with microwave sensors MRS-1 and next generation satellite IRS-II are slated for late 1990s.

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IRS-1C/1D SATELLITE SPECIFICATIONS

Weight : 1350 Kgs	3-Axiz Stabilised
Power : 872 W	Orbit : 817 Kms
Data : X-bands	Sun Synchronous
TTC : S-Band	

IRS-1C/1D PAYLOADS - SPECIFICATIONS

	LISS-III Multi-spectral Sensor (um)	Wide Field Sensor (WIFS) (um)	Panchromatic Sensor (PAN)(um)
Spectral Bands	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.75	0.62-0.68 0.77-0.86	0.50-0.75
Spatial Resolution	23.6 m	188 m	< 10 m
Swath	141 Km	770 Km	70.50 Km
Radiometric Resolution	128 grey levels	128 grey levels	64 grey levels
Revisit Capability	24 days	5 days	5 days

(Source : IRS Newsletter)

RS SATELLITES IN 1990

WORLD SCENARIO :

ASIA

ASIAN PERSPECTIVE OF SPACE

Amongst Asian countries, 1990s are likely to see a surge in space activities, largely related to immediate benefits, with the exception of Japan which, with USA, Europe and USSR, will engage in sophisticated space activities. While China is going to concentrate on booster business and development on the lines of long March rocket, Republic of Korea will enter the business of satellite construction. Thailand, and Indonesia will focus on remote sensing and communication related applications.

JAPAN

Advanced Earth Observation Satellite scheduled for 1995 launch is a major satellite project of Japan. It is likely to ride the H-II Mini Shuttle (HOPE), the prestigious vehicle under development at the National Space Development Agency of Japan (NASDA). A tracking and data relay satellite is another related development likely to materialise by end of decade. (Aerospace America).

SOVIET UNION

Soviet Wisdom

Soviet stipulate to augment their MIR-1 space station by two modules called specktor and Prirode. These modules scheduled for 1994 launch by Soviety Shuttle Buran will carry microwave and infrared sensors to measure the ozone layer and atmospheric pollutants.

RS Data from USSR

Soviet imagery are acquired from 5 m resolution KFA-1000 camera onboard MIR space station and Resurs satellite through film recovery capsules.

Current practice of selling these photographic products will change. Once EOSAT takes over as marketing dealer for these images and stands selling them after digitisation and enhancements. With resolutions reaching as sharp as 2 m, these images, the best in civilian area, will give a run to main market contender the SPOT. (Space Spectrum).

SOUTH KOREA

First RS satellite is likely to be launched by 1993 for survey and monitoring of fishing and farming resources.

INDONESIA

Indonesia and the Netherlands are jointly developing Tropical Earth Resources Satellite (TERS) to be launched in 1990s. It will acquire data four times a day in the equatorial belt of ± 10° latitude using a pointable sensor, in order to obtain cloud free images.

AUSTRALIA

This continental country foresees RS a prime tool for gathering information about its natural resources, particularly the mineral resources. It has plans afoot to use the space-based sensor data in a big way from Earth Observation System (EOS) planned by US and its partners in space station mission. The country does not envisage to launch its own RS satellites in immediate future but it has armed itself with an impressive array of expertise through the sustained effort of Central Scientific and Industrial Research Organisation (CSIRO) office of space science and applications which works closely with other departments and private firms. The country has earth stations for data reception, has developed aerial CO2 laser sensor for mineral exploration, is marketing powerful softwares for image processing (PC-compatible, micro BRIAN, DISIMP) and has plans to start its satellite launch vehicle development, apart from the famous Cape York space project.

EUROPE

EUROPEAN SPACE AGENCY

ESA has an ongoing earth observation program for land and ocean applications, apart from meteorological satellites. Apart from ERS-1 and 2, ESA has planned to contribute to manned space station program through Columbus polar orbiter which would carry microwave and spatial sensors.

FRANCE

After launch of SPOT-1 and SPOT-2 in 1985 and 1990, the French plan to launch SPOT-3 which has been already completed and awaiting the launch date which is most likely to be April 1993. SPOT-4 is presently under construction with the prime contractor of SPOT series, Matra Marconi Space of Paris. Next generation of SPOT satellite is likely to reach the Space by 1998. Although final decisions have not been taken, the next generation SPOT will have 5 m resolution and capability for high data rate for transmission of high resolution pictures. Incidentally SPOT image expects to attain self-sufficiency by 1998 and thus fund the fifth satellite or 1st next - generation satellite from its own revenue (SPACE NEWS).

NORTH AMERICA

UNITED STATES OF AMERICA

Under its Global Change Research Program, US plans to monitor the global environment, using Earth

Observation System which will comprise of numerous remote sensing satellites to be launched during next 15 years at a total cost of $ 30 bn. It will comprise two series of polar-orbiting platforms packed with different types of sensors. EOS will also includes Space Probes - the satellites which will be placed in different orbits either due to inherent sensor requirement or for prototypes testing. As many as 14 satellites are likely to be launched during 1990-96 period, as per current plan of NASA. Some of the EOS satellites are characterised below.

Satellite/Sensor	Mission Objective/ Characteristics
Upper Atmospheric Research Satellite (UARS)	Study of ozone layer (1991 launch)
Ocean Topography Experiment	Ocean Circulation Pattern (1992 launch)

Imaging spectrometers to be orbited under EOS open other exciting new possibilities for detailed 'in situ' spectral behaviour analysis (See HIRIS' Newsletter, Vol. 4, No. 4).

CANADA

With healthy allocation of more than $ 2 bn, Canada maintains a high profile in space. Its main RS lead lies in Radarsat, a polar satellite with sophisticated radar sensors. Due for launch in 1994, the spacecraft is being built by a Canadian private firm, at the total allocated budget of nearly $ 400 m under the program of Canadian Space Agency.

SOUTH AMERICA

REMOTE SENSING SATELLITE OF BRAZIL

First RS satellite of Brazil will be launched in 1992. The 115 kg satellite will be placed in orbit by an Ariane rocket as the Brazilian programme of launch vehicle development envisages the readiness of vehicle by 1993 or 1994 (COSSA).

HIGHLIGHTS OF FUTURE RS SATELLITES

Sr. No.	Satellite	Mission Objective	Sensor Characteristics
1.	IRS-1B (India)	National Natural Resource Mapping	LISS I & II sensor, same as IRS-1A
2.	IRS-1C (India)	National Natural Resource Mapping	- 4-band multispectral sensor (visible-MIR) (23.5 m resolution) - Panchromatic (10 m resolution) - Wide field sensor (Wifs) (180 m resolution)
3.	IRS-1D (India)		
4.	ERS-1 (ESA)	Monitoring Ice Fields and Ocean	- C-band Synthetic Aperture Radar (30 m resolution) - Radar Altimeter - Scatterometer - Scanning Radiometer (IR)
5.	ERS-2 (ESA)	Continuity of ERS-1 Service	Same as ERS-1
6.	ERS-1 (Japan)	Agriculture/Forestry Fisheries/Coastal Mapping	- Optical (visible-infrared) 7-band CCD based sensor - SAR
7.	Advanced ERS-1 (Japan)	-	- Sensors from US, France, Japan
8.	Radarsat (Canada)	Ice field mapping	- C-band SAR - Polar Sun Synchronous orbit - Many operating modes and beam control
9.	SPOT-3 (France)	Natural Resource Mapping	Same as SPOT-1 & 2
10.	SPOT-4 (France)	-do-	-do-
11.	Landsat-6 (USA)	-do-	- Enhanced Thematic Mapper (ETM) (6 bands in VIS-MIR, 1 in TIR) - Panchromatic Sensor (15 m resolution)
12.	Landsat-7 (USA)		- Modified ETM (6 spectral bands) - Panchromatic (15 m resolution) - 4 Thermal bands (60 m resolution)

RS SATELLITES IN 1990S

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
India	IRS-1B		IRS-1C			IRS-1D	IRS-II/ MRS-1			
USA		LSAT-6				LSAT-7				
	<------------				EOS					------------>
France			SPOT-3			SPOT-4		SPOT NEXT GEN		
Japan		ERS-1			Advanced ERS					
Canada				RADARSAT						
Europe (ESA)	ERS-1			ERS-2						
Brazil*		RS Sat								
USSR*		RS Sat (Digital)								
South Korea*			RS Sat							

* First RS satellite of Brazil, First USSR satellite with digital imaging capability, first satellite from S Korea.

\+ EOS Earth Observation System will comprise a series of satellites during 15-year period.

SPACEVISTAS : GLIMPSES OF 1990s

SPACE EDUCATION

Shortage of trained manpower for space endeavours in private and public sector is one of the likely problem areas - for the decade and even beyond. It is generally believed that the decade and the coming century will see a shortfall in trained manpower (science and engineering) to the tune of 30% in US.Remedial measures assume multiple dimensions, sometimes according to country-wise perceptions. For example US finds the divergence between engineering and policy/management branches as headeache and plans to introduce multi disciplinary courses to get its future graduates trained. European countries seem to have a more livelier way of promoting education at broad and informal as well as formal level. Examples are: German system of apprecticeship. in space industry, French way of hands-on education in RS for tenth graders, teacher training, public awareness programs, and clubs with rocketry experiments.

SPACE MATERIALS

Aluminium and its alloys are the work horse materials for today's payloads and spacecraft structures. Search for better materials accruing such advantages as reduced cost, high structure-to-payload rates and reduced launch cost, and almost equivalent strength continues. One of the promising materials is beryllium, which offers 1.4 times more strength and 40% reduction in density as compared to aluminium. Still more promising category of materials are advanced composites. The most ubiquious composite may be RCC (Reinforced Cement Concrete) but the modern composites being developed under highly guarded secrecy in terms of their structure, material combination and processes; promise to be the wonder materials of tomorrow. These will excel any of the known properties of metallic/non-metallic materials and offer unsurparssed advantages in aerospace industry. (ISREL + other sources).

SPACE STATIONS

A dream-like home in the vicinity of stars is indeed a tempting idea. But no one will do that just for the sake of sheer romance. Not even for national pride - although such high technology ventures do invariably turn up as show case for nation's economic and technological prowess. High-cost and high-risk nature of manned as well as unmanned space stations is pushing the nations towards more and more international alliances. They plan to do it simply because benefits are immense - in terms of earth observations, microgravity manufacturing and vacuum advantages of deep space.

Major player in the game of space stations is USSR with its MIR-1 space stations already orbiting happily since 1986. US with its partners will steal that lead with its proposed Freedom space station. European community wants to join with their mini-add-on space station called Columbus. All these projects are plagued by recurring financial allocation problems and occasional howl of protest from those marginalised group of scientist who feel the pinch of funds- swallowing nature of space stations. But these are the indicators to the shape of things in 1990s and beyond.

AEROSPACE PLANES

Biggest problem with rockets is that they carry and use oxygen - enormous loads of it, while still passing through the lower layers of atmosphere where oxygen is aplenty. It is like someone travelling through India with his own cow. Aerospace planes proposed and being built by different countries overcome that problem by travelling through air like a jet plane with superior fuel efficiency and changing to rocket mode only in thinner layers of atmosphere or in space. Of course such a plane is multi-billion dollar proposition as it incorporates various advanced R&D elements. Once built these planes will cut down the launch cost by ten times from the present rate of $ 3000 per pound. Some of the proposed aerospace planes and their lead countries are X-30 National Aerospace Plane (NASP) - USA, HOTOL (Horizontal Take Off and Landing) - Britain and Saenger (Germany).

The passenger versions of these planes (US calls it Orient Express) will cut down the travel time drastically (Tokyo to New York in 2 hours).

FUELLESS MANOEUVRES

Soviets, at Institute for Space Research are developing one of the most economical spacecrafts 'Regatta' which could serve as general platform for earth resource satellites in post-1995 phase. 'Regatta', named so because it will use small solar sails for attitude control and stabilisation,could be rolled for general sales for a paltry $ 15 m, launch and payload included.

PLANETARY PROBES

Magellan

NASA probe launched in 1989 to map the Venus surface using synthetic aperture radar, 70-250 m resolution image received since September 1990 revealed a lot about Venus.

Galileo

NASA probe launched in 1989. It will examine earth's magnetic field, map the moon's toside in near-infrared region and reach Jupiter in 1995.

ISY PLAN

Following are the ten projects to be undertaken during International Space Year (1992) in order to evaluate the health of earth using satellite remote sensing.

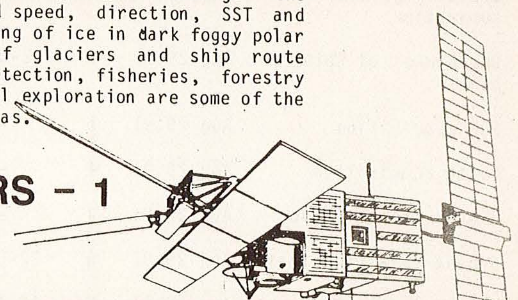
1. Enhanced greenhouse effect detection
2. Ocean variability and climate
3. Polar strateospheric ozone
4. Land cover change
5. Productivity of the global ocean
6. Global tropical forest monitoring
7. Sea surface temperature
8. Polar ice extent
9. Global change encyclopaedia
10. Global change atlas

ERS-1

First European Remote Sensing Satellite (ERS-1) of European Space Agency was launched on July 16, 1991 by ARIANE launcher from Kourou, French Guiana. The 2384 kg satellite has been placed in polar sun-synchronous orbit with inclination of 98.5° and perigee of 767 km and apogee of 787 km with mean local time at descending node (equatorial crossing) of 10.30 with a 3-day repeat cycle. Built by Dornier Germany around a 'multimission platform' similar to that of SPOT programme, the satellite carries a set of active microwave sensors and complementary sensors for remote sensing and environmental monitoring of oceans, ice and land. The real time SAR data available for 10 minutes per orbit will be relayed to ground sations (Landsat-type receiving stations, including India) in X-band. Apart from SAR regional service, there is a provision for low bit rate global service which can be availed through onboard storage. Some selected products called fast-delivery products will be generated and delivered within 3 hours from observation. ESA plans to evaluate engineering and geophysical performance of the satellite during commissioning phase of 3 months. Onboard sensors like laser corner reflector, PRARE package, altimeter and microwave sounder can be used to compute the orbit down to decimeter level.

Built with a total cost of 730 MAU (1 Accounting Unit = ± 1.2 US $), ERS-1 programme will lead to a number of commercial/operational applications. Weather and sea-state forecasts through the measurements of wind speed, direction, SST and water vapour, monitoring of ice in dark foggy polar regions for study of glaciers and ship route planning, oil spill detection, fisheries, forestry and agriculture and oil exploration are some of the likely application areas.

ERS - 1



ERS-1 PAYLOAD

+ C-BAND ACTIVE MICROWAVE INSTRUMENTATION (AMI)
  - SYNTHETIC APERTURE RADAR (SAR) with two operating modes :
    - . Full imaging mode : SAR mode
    - . Sampled imaging mode : Wave mode
  - WIND SCATTEROMETER : Wind mode
+ Ku-BAND RADAR ALTIMETER
+ ATSR/M
  - . Infra-red Along Track Scanning Radiometer (ATSR)
  - . Two-frequency Microwave Sounder (M)
+ S/X BAND PRECISE RANGE AND RANGE RATE EQUIPMENT (PRARE)
+ PASSIVE LASER CORNER RETRO-REFLECTORS

Geophysical Measurements and ERS-1 Performance Parameters

Main Geophysical Parameter	Range	Accuracy	Main Instrument
Wind Field			
– Velocity	4-24 m/s	± 2 m/s or 10 % whichever is greater	Wind Scatterometer & Radar Altimeter
– Direction	0-360 deg	± 20 deg	Wind Scatterometer
Wave Field			
– Significant Wave Height	1-20 m	± 0,5 m or 10 % whichever is greater	Radar Altimeter
– Wave Direction	0-360 deg	± 15 deg	SAR Wave Mode
– Wavelength	50-1000 m	20 %	SAR Wave Mode
Earth Surface Imaging – Oceans – Coastal Zones – Sea-Ice – Land	80 km (minimum swathwidth)	Geometric/Radiometric Resolutions: a) 30 m/2,5 dB b) 100 m/1 dB	SAR imaging Mode
Altitude			
– Over ocean Polar Ice-Sheets	745-825 km	2 m absolute ± 10 cm relative	Radar Altimeter
Satellite Range		± 10 cm	PRARE
Sea Surface Temperature	500 km swath	± 0.5 °K	ATSR (IR)
Water Vapour	in 25 km spot	10 %	µW Sounder

IRS-1B Launched

IRS-1B the 'follow on satellite' of the IRS series was launched by Vostok Rocket from the Soviet Cosmodrome at Baikonur on 29th August, 1991 at 12:18:44 hours. In sharp contrast to the severe cold weather during the launch of its predecessor IRS 1A the weather during 1B launch was in its pleasant twenties.

Like its predecessor the journey of the satellite to its abode in space went off with clock-work precision. The following table shows the details of the critical events.

IRS-1B LAUNCH HIGHLIGHTS

Critical Events	Date	Orbit No.	Time (IST) HR-MIN-SEC
Vostok Life-off	Aug 29,91		12-18-44
First stage separation	Aug 29,91		12-20-44
IInd stage separation	Aug 29,91		12-25-54
Nose cone jettisoning	Aug 29,91		12-28-49
IRS-1B injection and separation	Aug 29,91		12-30-15
Deployment of solar panel	Aug 29,91	1	12-32-15
Sun acquisition	Aug 29,91	1	--
Earth acquisition	Aug 29,91	4	--
3-Axis stabilisation	Aug 29,91	4	--
S-band data link test	Aug 29,91	6	22-01-30
LISS-1 operated in normal mode	Aug 30,91	14	10-43-55
X-band data link test	Sep 6, 91	112	10-40-35
LISS-II A&B operated in normal mode	Sep 6, 91	113	12-15-14
LISS-1 & II A&B simultaneously operated in normal mode	Sep 7, 91	126	10-35-45
Completion of orbit manoeuvres for attaining IRS referencing scheme	Sep 27,91	--	--

After the soviet launcher completed its designated taks of putting the satellite into a near circular orbit (see table 2), the functions of IRS-1B satellite started. With the smooth deployment of solar panels the energy source for all the satellite function was guaranteed. Satisfactory functioning of all the major systems of the satellite, ensured sun-acquisition, earth acquisition and 3-axis stabilisation of the satellite. In the night the S-band link tests, a pre-requisite for LISS-1 operations, were successfully carried out. On 30th August the first image from the IRS-1B satellite was received at about 10-44-30 hours. Same day the data received was converted into photographs.

Table 2 : Orbit Parameters - IRS-1B

	At Injection	After Orbit Manoeuvres
Semi-Major Axis	7263 Kms	7282.38 Kms
Perigee	851 Kms	891.50 Kms
Apogee	918.27 Kms	916.90 Kms
Inclination	99.24°	99.14°
Time Period	6167 Sec	6191.69 Sec
Eccentricity	0.0046	0.00175

The LIS-IIcameras were switched on for the first time on 6th September and on 7th September both LISS-I and LISS-II cameras were simultaneously operated. With this all the sub systems of the satellite had been successfully checked out. The fine tuning of the orbit to achieve the designated path row referencing scheme was then initiated.

The orbit manouvers were completed by 27th September. The IRS 1B satellite is now performing its picture taking tasks regularly such that it is 11 days behind the IRS-1A satellite with respect to path calender. Thus the repetitivity has now come down from 22 days to 11 days. The initial phase performance evaluation exercises are in progress and the data from both IRS 1A and 1B is now available for users.

(Contributed by Shri A S Kiran Kumar, Head, Sensor Systems Division, EOSDG/RSA, Space Applications Centre, Ahmedabad)

Launch Day Forecast for IRS-1C and 1D

IRS series of satellites seem to be tuned to the family of Dr. R R Navalgund (Head, Land Resources Division, RSAG-SAC). How else can one explain the sheer incidence of launch dates of IRS-1A (March 17) and IRS-1B (August 29, 1991) coinciding with birth days of Dr. R R Navalgund and Dr. (Mrs.) Veena Navalgund respectively. And if past is any indicator to the future, IRS-1C and 1D should maintain the launch dates of April 2 and March 3, the birth dates for Navalgund's daughter and son respectively. You might aptly guess that back home, instead of usual 'Happy Birthday to You' Navalgunds might be celebrating those dates with blasting chorus of 10-9-8-7.....

REMOTE SENSING IN MILITARY SURVEILLANCE

Aerial photography has been used for surveillance and mapping purposes since the early part of the century. Remote sensing techniques have mainly been used for non-military applications such as geology, agriculture, forestry, hydrology, etc. since world war II, which are of importance to mankind. Nevertheless, their use in military surveillance continues unabated and is being exploited to the full. Today, when superpowers are strengthening their military resources and planning defense strategies it is anybody's guess as to how they are getting the stock of the military resources of the other country. In the recent gulf war, the United States made an extensive use of reconnaisance satellite imagery over Iraq and Kuwait to plan attack missions and assess bomb damage. Tracking of mobile scud launchers at night was done using infrared and radar data. This brings to light the vulnerability of today's armies to the remote sensing technology. Today, space-based military assets prove a decisive factor in any war.

The Soviet Union has till date launched 2000 Cosmos satellites majority of them for military purposes and approximately half of these have been surveillance satellites. Soviet imaging reconnaisance satellites employ capsules which are recovered intact with film at the end of the missions which are of short durations. The United States developed photographic reconnaisance satellites within the 'Discoverer' program. Close-look and area surveillance satellites also appeared in early seventies. Big Bird satellites provided close-look imagery with a resolution of atleast 300 mm from heights around 160 km. KH-11 satellites have 150 mm resolution from a height of 250 km.

Commercial Satellites

Commercial imaging satellites have only limited usefulness in news or tactical intelligence gathering because of two limitations- timeliness and resolution. The most critical factor for successful military operations is rapid data return. Data delayed by days or even hours can be useless for tactical operations. However, commercial satellites with modest resolution sensors have been used for several specific applications like monitoring nuclear proliferation, assessing nuclear missile sites and monitoring underground nuclear tests. They have also been used for crisis decision-making, multilateral peace-keeping and treaty verification, and cross-border conflicts. Data from these satellites is useful in strategic studies of neighbouring countries by countries which cannot afford to launch their own surveillance satellites. Even with its own powerful array of spy satellites, the U.S. government has found commercial imaging satellites useful. The DOD used commercial satellite photographs from the French SPOT satellite to illustrate Soviet military developments in 1988. However, data from these satellites are insufficient for determining the functional or structural details of a target critical to effective military analysis. Most important, this level of detail is insufficient for interpreting the operational status of the object and hence its impact on military operations.

Reconnaisance Satellites

There are technological differences in altitude, orbit, inclination, resolving power etc. between reconnaisance and non-military satellite. The most important difference is in the resolving power which in observation satellites is only 1/200 to 1/1000 of that of military monitoring satellites. The perigee of military satellite is said to be about 150 km and resolving power upto a few cms. On the other hand non - military satellites orbit at an altitude of about 250- 900 km and have resolving power ranging from 10 m to a few kms. It is suggested that a minimum ground resolution of twenty feet is required for arms control inspection. A ground resolution of two feet is generally needed for studying man-made features of military interest. There are four main types of reconnaissance satellites, photo-reconnaissance, electronic reconnaissance, ocean reconnaissance and early-warning satellite. The first type carry photographic and television cameras, multi-spectral scanners, infra-red sensors and microwave radars. These provide information about hardware. Electronic reconnaissance satellites are also called electronic intelligence (ELINT) satellites or ferret satellites. They carry equipment designed to monitor and detect radio signals by the opponents' military activities. Ocean surveillance satellites are used not only to track naval ships but also to determine sea conditions. A better understanding of the characteristics of oceans enables the design of better sensors for submarine detection. Space-based sensors include radar that can see through clouds and infra-red detectors. Early warning satellites give warning of a surprise attack by ballistic missiles. The warnaing time is around 30 minutes. Such satellites using IR sensors can observe the launches of intercontinental ballistic missiles (ICBM) and transmit the information to ground station.

Visible and Infrared Sensors

Photo-reconnaissance sensors can perform well only during daylight and clear weather. 'Close-look' photography can make possible the detection and identification of most military targets on the ground. 'Area surveillance' cameras are employed under circumstances in which relatively low resolution when accompanied by a broad view gives more interpretable image than a high resolution photo of a limited area.

The resolution required for detection, recognition identification and description of various targets varies. Area-surveillance imagery in resolution range between 1-3 metres may be infrared as capable of providing precise or near-precise identification of most military targets, while close-look image in resolution range between 0.1- 0.5 metres would enable one to get target description and analysis. Digital data from multispectral sensors allow for production of false colour composites which make the camouflaged objects more readily detectable. For example the human eye cannot readily percieve by looking at conventional colour photos the difference between ordinary green paint and a background formed by deciduous leaves, whereas false color infrared film renders the foliage bright red and the paint blue. It is also possible to differentiate the dead grass from green grass using their spectral signatures and thus detect the camouflaged objects from the surroundings.

Unlike visible sensors, thermal infrared sensors provide round-the-clock coverage. Infrared systems can view thermal signatures of targets. Because vehicle engines heat up targets, they show up in bright contrast to the background which is normally cooler. They detect the thermal emissions from the rocket plumes during the boost phase and provide an element of early warning to command centres. Infrared sensing techniques have the ability to sense movement of even relatively small heat sources, such as small groups of moving men.

ELINT

Not all surveillance is at visible or near-infrared wavelengths. Active probing of targets by radars carried onboard satellites in the side-looking or synthetic aperture modes can yield imagery of sufficient resolution for military purposes. Passive monitoring of electro-magnetic emanations from earth-based radars can provide information invaluable for the design of counter measures of electronic warfare. The interception of radio signals of coded messages and data is a standard electronic intelligence (ELINT) gathering technique. Elint satellites also known as ferrets act as 'ears' in space. They have many applications such as locating radio transmitters, eavesdropping on communications and monitoring the telemetry from missile tests. These satellites gather data on missile testing, new radars and many other types of communication traffic. Not only can they locate systems producing electronic signals but also measure the characteristics of the signals so as to be able to plan penetration of defences.

Arms Control Verification

There are many who consider that the 'open skies' policy initiated over ten years ago which ensures that agreements can be easily monitored by the use of space systems is a major contributor to continuing world peace on a global scale. Today remote sensing technique has been identified as a tool which allows identification and monitoring of military activities and developments in great details. It is because of space-borne surveillance that treaties like SALT have been made possible.

Radars, IR sensors and photographic sensors are used for the arms control verification process. These verification methods are efficient because the introduction of new missile systems has to go through research, development, testing, production and deployment phases. It is very improbable that the system could go through several or all of these phases without detection. Verification of chemical weapons can be done by monitoring from satellites the actual situation and state of objects (e.g location and territorial structure of facilities stockpile areas etc. and the operational status of production units) and relevant chemical substances in the atmosphere. Stockpile installations can in principle be identified by improved photographic techniques and high ground resolution.

Future Scenario

Despite the impressive record of performances of satellites in surveillance, there have been certain technical limitations. In the foreseeable future, non- scanning or staring sensors will remove many of the technical constraints that limit performance and reliability. The next generation of satellites will probably incorporate several new technologies- notably, mosaic sensors and advanced cryogenic coolers besides charge couple devices- which together promise an improvement of several orders of magnitude in resolution and signal-to noise ratio. CCD technology will enable the signal processing to be performed onboard the satellite and hence scale down the ground-based operation. The staring mosaic sensors will provide continuous coverage of potential launch points, providing additional warning time. To achieve maximum sensitivity of staring mosaic sensors the sensing element will require a powered cryogenic cooling system.To achieve the high resolution needed to detect and trace 'dim' objects from geosynchronous orbits, deployment of very large optical structures that incorporate adaptive optics and other technologies is envisaged.

Though it has been claimed that space reconnaisance has promoted disarmament/arms control, the military use of photo-reconnaisance has an intent which is rather aggresive. Whether the superpowers and increasingly the developing countries will use these techniques for wartime activities or for promoting international peace remains to be seen.

(Contributed by Mrs. Tara Sharma, LRD/RSAG/SAC, Ahmedabad).

Do you agree with Some New Definitions

If it moves, it is Biology

If it reacts, it is Chemistry

If it doesn't move, does't react and still works, it is Geology

If it doesn't work, ~~it is~~ call Physics

(Fun time definitions from anti-physics lobby of LRD/MWRD, Correction by pro-physics Editor)

INDIAN SOCIETY OF REMOTE SENSING - AHMEDABAD CHAPTER

Annual Report (April 1, 1990 to March 31, 1991)

As on March 31, 1991, the chapter has 1 honorary member, 100 life members, 40 orginary members, 7 sustaining members, 3 patron members and 35 members from outside chapter.

The council met three times to transact the business of the chapter.

Lectures, Exhibition etc.

° The Chapter has been organising an annual "Shri Laxminarayan Calla Memorial Lecture". The fourth in the series was delivered by Prof. B L Deekshatulu, Director, National Remote Sensing Agency, Hyderabad on "Remote Sensing for National Development" on January 11, 1991.

° Indian Remote Sensing Satellite (IRS-1A) completed three years of successful operations in the orbit on March 17, 1991. To mark the occasion the chapter organised following functions.

Interview on Doordarshan

Shri Pramod Kale, Director, Space Applications Centre and Dr. George Joseph, Chairman ISRS Ahmedabad Chapter were interviewed. The programme was telecast on March 14, 1991.

Exhibition

A two day exhibition was organised at the Bhaikaka Bhavan, Ahmedabad during March 17-18, 1991. The exhibition was inaugurated by Shri O P N Calla, President, IETE. A souvenir was released on this occasion. The exhibits were open to public on both days from 1000 hours to 1930 hours. There were exhibits on science of remote sensing, satellite images of different parts of the country and its applications in various disciplines. Various models of satellite and launch vehicle were displayed. Video films were also screened. Large number of people, particularly students visited the exhibition. An image of Ahmedabad taken by IRS, a souvenir and a paper model of IRS were distributed to visitors.

Popular Lecture

° A popular lecture on the "Role of Remote Sensing in National Development was organised at the Bhaikaka Bhavan on March 17, 1991. Prof. P R Pisharoty, Professor Emeritus, PRL, delivered the lecture. Shri Pramod Kale presided over the function.

° A lecture on "Remote Sensing in Geomorphology" was delivered by Dr. S R Nayak, Scientist, SAC in the Department of Geography, Gujarat University.

R&D Activity

As per decision taken in the last AGM, an R&D activity has been taken up with a non-government organisation to demonstrate the role of remote sensing in wasteland developments. This activity is in progress in the Dholka Taluka of Ahmedabad district.

Publications

Three issues of the newsletter has been brought out this year and the fourth one is ready for printing. A souvenir containing article in Gujarati, Hindi and English was brought out on the occasion of IRS-1A celebration. A colour image of Ahmedabad city along with map was published.

ISRS Award

The Indian Society of Remote Sensing (ISRS) has instituted 'The Indian National Remote Sensing Award' to be given to the individuals for outstanding contribution in the field of remote sensing. The award consisting of Rs. 5,000/- (rupees five thousand only) in cash, citation and a medal is proposed to be given every year during the annual convention of the Society.

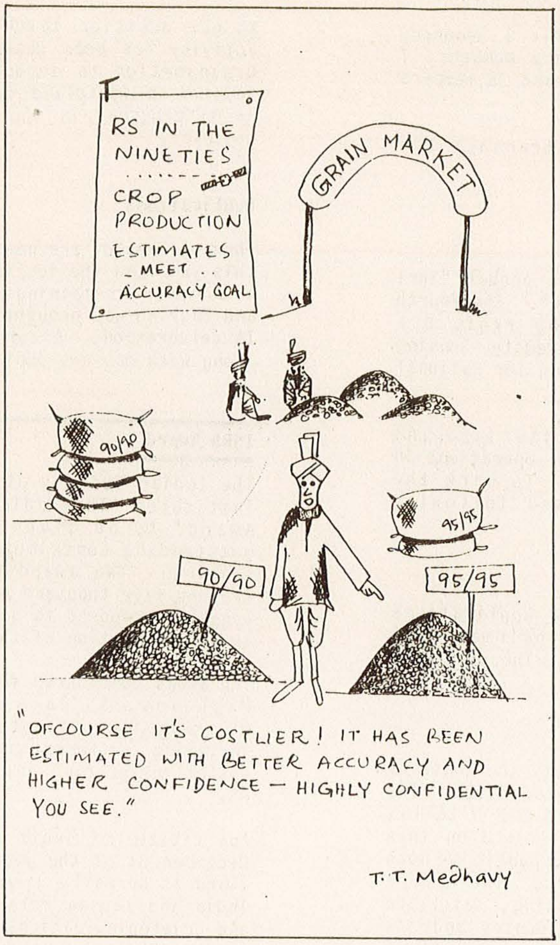
The areas considered for award are RS Platforms and Payloads, RS Data Reception, Processing, Dissemination and Interpretation, RS Applications including software and hardware development and system engineering and management in the field of RS.

Any citizen of India below 45 years of age as on December 31 of the year of award is eligible. The award is normally given for work primarily done in India and having relevance to India in particular and developing nations in general.

Nomination for the award can be forwarded by Presidents of scientific societies, Vice Chancellors/Dean of Universities including IITs, Directors of R&D organisations, State/Central Agencies, Cooperative and Private R&D organisations, Chairman of Space Commission, UGC, ONGC, members of Planning Commission and Secretaries of science/technology and related departments of state/centre.

Nominations in prescribed format should be sent before October 31 of the year to The President, ISRS, IIRS Campus, 4 Kalidas Road, Dehra Dun 248 001. The awardees will be selected by ISRS Executive Council and the award will be presented during annual convention of the Society.

Nominations have been invited for 1991. Details may be obtained from Society/Chapter, Headquarters.



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