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SATELLITE TELECOMMUNICATIONS: A FIELD FOR HORIZONTAL CO-OPERATION  
IN THE PEACEFUL USES OF OUTER SPACE \*/

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### Summary

In this paper, which was prepared for the First Latin American and Caribbean Meeting of Governmental Experts on Co-operation Mechanisms in the Field of Outer Space, an attempt is made to suggest specific ways of utilizing space technology to promote the development of the countries of the region by means of a joint effort on their part to establish a regional satellite telecommunications system.

Tables are included which provide an overview of the use of satellite telecommunications systems in the countries of the region. These data have been taken from publications of INTELSAT, INMARSAT and private companies in this field, as well as from some of the national case studies which were prepared for UNISPACE 82.

The author discusses the countries' development needs, as set forth in these case studies, and the ways in which satellite communications systems can help to fulfill them.

The experiences of other countries are described in the annexes. When considered in relation to the countries of the region, these experiences illustrate the advantages of utilizing space technology, which joint technical co-operation efforts could make feasible.

The conclusions presented in this paper include proposals for the formulation of specific projects by telecommunications experts of the region and for the establishment of at least one Latin American office to co-ordinate these activities.



## Introduction

The development of space technology over the past 25 years has opened up new social and economic development opportunities for the countries of the region. Some Latin American countries are not taking advantage of these opportunities because, as individual nations, they lack the trained personnel and economic resources to do so. Similar shortages are slowing down progress in other countries of the region that are already making use of these technological tools. Only one Latin American country appears to have the necessary "critical mass" to conduct programmes for utilizing existing space technology and, indeed, that nation is now approaching a level of autonomy similar to that of other countries which conduct space activities.

The Latin American countries belonging to the International Telecommunications Satellite Organization (INTELSAT) as of 1981 are listed in table 1, together with the name of the national institution which signed the INTELSAT Operating Agreement, information on the number of earth stations each country has and the percentage of its investment, based on the country's use of the system. The system's revenue is provided by user fees, and after its operating expenses are deducted from this sum, the balance is distributed to the members in proportion to their investments. The above information was obtained from the annual report of INTELSAT for 1981.

The International Maritime Satellite Organization (INMARSAT), which was created in 1976 on the initiative of the International Maritime Organization (IMO), had only three member countries in Latin America (Argentina, Brazil and Chile) as of February 1982 (see table 1).

Table 1

## INTELSAT MEMBER COUNTRIES IN LATIN AMERICA

Country	Signatory	Earth stations	Contribution to INTELSAT (percentages)
Argentina <u>a/</u>	Empresa Nacional de Telecomunicaciones de la República Argentina (ENTEL-ARGENTINA)	3 norm. A antennas (BALCARCE, BOSQUE ALEGRE) 33 non-std. fixed antennas 3 non-std. mobile antennas	1.275909
Bolivia	Empresa Nacional de Telecomunicaciones	1 std. A antenna (TIAWANACU)	0.050000
Brazil <u>a/</u>	EMBRATEL (Brazilian Telecommunications Company)	2 std. A antennas 1 std. B antenna (NATAL)	3.046065
Colombia	Empresa Nacional de Telecomunicaciones de Colombia (TELECOM)	2 std. A antennas (CHOCONTA)	0.728846
Costa Rica	Instituto Costarricense de Electricidad		0.050000
Cuba		1 std. B antenna (CARIBBEAN)	
Chile <u>a/</u>	Empresa Nacional de Telecomunicaciones S.A. (ENTEL-CHILE)	3 std. A antennas (LONGOVILO)	0.0579289
Ecuador	Instituto Ecuatoriano de Telecomunica- ciones (IETEL)	1 std. A antenna (QUITO)	0.411395
Guatemala	Empresa Guatemalteca de Telecomunicaciones	1 std. A antenna (QUETZAL)	0.050000
Haiti	Telecommunications d'Haiti S.A.	1 std. A antenna (J-C DUVALIER)	0.192841

a/ These countries also belong to INMARSAT.



Table 1 (conclusion)

Country	Signatory	Earth stations	Contribution to INTELSAT (percentages)
Honduras	Empresa Hondureña de Telecomunicaciones (HONDUTEL)		0.050000
Jamaica	Jamaica International Telecommunications (JAMINTEL)	1 std. A antenna (Prospect Pen)	0.534451
Mexico	Mexican Government	2 std. A antennas (TULACINGO)	0.618144
Nicaragua	Compañía Nicaragüense de Telecomunica- ciones por Satélite	1 std. A antenna (MANAGUA)	0.050000
Panama	Intercontinental de Comunicaciones por Satélite S.A. (INTERCOMSA)	1 std. A antenna (UTIBE)	0.050000
Paraguay	Administración Nacional de Telecomuni- caciones (ANTELCO)	1 std. A antenna (AREGUA)	0.121897
Peru	Empresa Nacional de Telecomunicaciones del Perú (ENTEL-PERU)	1 std. A antenna (LURIN)	0.495229
Dominican Republic	Compañía Dominicana de Teléfonos	1 std. A antenna (CAMBITA)	0.050000
Suriname		2 std. A antennas (CAMBITA)	

INTELSAT in Latin America: The countries' needs as identified  
in some national case studies presented at UNISPACE 82

The present status of telecommunications use in some of the countries of the region is described in a summary based on the case studies prepared by their governments for the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) (see table 2).

Table 3 provides information on the use of domestic satellite systems in Latin America.

It is interesting to note that even the small number of countries appearing in table 2 provides a clear indication of the interest which exists in utilizing telecommunications satellite technology in unconventional applications not provided for by present systems, such as narrow-band systems for use in remote areas requiring only a few telephone channels. There is also specific interest in exploring the application of telecommunications satellites to tele-education systems. It is also important to note that three of the seven countries in the sample are interested in establishing telecommunications systems based on satellites of their own.

A number of Latin American countries also need to settle new territories, whose resources could help bring about a global economic improvement. To do so, they must make it less difficult or more attractive to live in these remote regions by bringing cultural events, entertainment, information and education to such areas. The creation of new human settlements could help to reduce the growth rate in Latin American cities. Telecommunications satellites are the most appropriate means of accomplishing these objectives.

Other telecommunications needs in the region:  
information systems

Other existing needs include the establishment of data bases that can be accessed via satellite (such bases being necessary for the social and economic progress of the Latin American nations), and the establishment of satellite-linked information networks.

Both of the above are manifestations of the marriage between computers and telecommunications, which has given rise to the new field of tele-information or telematics; this field is regarded as a key factor in the current information revolution.

Table 2

## SATELLITE TELECOMMUNICATIONS IN SOUTH AMERICA

(Summary based on some of the national case studies presented at UNISPACE-82)

Country	International system	National system	Other systems, plans, future needs
Argentina	<p>INTELSAT, operated by ENTEL-ARGENTINA since 1969.</p> <p>Earth stations (standard A):</p> <ul style="list-style-type: none"> <li>- Balcarce I, primary satellite</li> <li>- Balcarce II, major step 2</li> <li>- Bosque Alegre, major step 1</li> </ul> <p>SERVICES: Telephones - 850 channels (DID) Telex</p> <p>ENTEL-ARGENTINA is the signatory to the INTELSAT Operating Agreement</p>	<p>National telecommunications system via INTELSAT satellites.</p> <p>Objective: To serve regions of Argentina which cannot be linked up to the rest of the country by other means.</p> <p>It consists of 33 fixed earth stations. It will operate on an allocation-by-demand system.</p> <p>Services: telephones, telex, television, radio links.</p> <ul style="list-style-type: none"> <li>. Limited-capacity local hook-ups (4 channels) for isolated cities (northern network, southern network);</li> <li>. Back-up links between Buenos Aires and the locales of existing radio hook-ups for use in the event of an interruption of radio communication;</li> <li>. A one-channel telephone hook-up between Buenos Aires and three stations in Antarctica.</li> </ul>	<p>INMARSAT. In its capacity as a member of the International Maritime Organization (IMO), Argentina took part in the creation of INMARSAT. It represents South America in the Council of INMARSAT. It plans to set up a coastal earth station.</p>
Bolivia	<p>INTALSAT, operated by ENTEL-BOLIVIA since 1978.</p> <p>Tiawanacu earth station (standard A).</p> <p>By late 1982, 70 telephone channels and 120 international telex channels were in operation.</p>	<p>Bolivia plans to set up a national satellite telecommunications system.</p> <p>Objective: To provide telecommunications services to the northern part of the country, whose inaccessibility keeps it isolated from the rest of Bolivia.</p>	

Table 2 (Cont.)

Country	International system	National system	Other systems, plans, future needs
Bolivia (cont.)	There were plans for DID to come into use in 1983. By 1985, the utilization of 207 telephone and 250 telex channels was projected.	The project provides for: 5 earth stations 1 command station Pre-assigned circuit mode. Initially, there will be 50 circuits (100 channels). An INTELSAT transponder will be leased.	
Ecuador	Ecuador joined INTELSAT in 1972. It has an earth station (standard A) in Quito which is operated by the Ecuadorian Telecommunications Institute (IETEL). Capacity: SCPC (single channel per carrier), 56 kb/s.		The Government of Ecuador intends to initiate studies regarding the placement of a geostationary satellite system of its own within the geosynchronous orbit segment corresponding to the longitudes of Ecuadorian territory. In addition to improving telecommunications in the country, this system might also be used by other countries in the region.
Peru	ENTEL-PERU operates an INTELSAT standard A earth station in Lurín.	The Sistema de Comunicaciones del Perú is a domestic satellite communications system with 8 standard B earth stations.	Peru is interested in: <ul style="list-style-type: none"> <li>. Expanding the commercial use of satellite communications;</li> <li>. Having a space segment of its own for telecommunications;</li> <li>. Setting up economical narrow-band earth stations to provide communications services to isolated areas;</li> <li>. Continuing with the training of Peruvian personnel in this field;</li> <li>. Conducting research on methodologies for tele-education via telecommunications satellites;</li> <li>. Designing a nationwide tele-education system;</li> <li>. Training Peruvian personnel in modern tele-education techniques.</li> </ul>

Table 2 (Concl.)

Country	International system	National system	Other systems, plans, future needs
Colombia	Colombia's participation in the INTELSAT system is handled by the Empresa Nacional de Telecomunicaciones de Colombia (TELECOM). Earth station Chocontá 1 (standard A) Chocontá 3 (standard A)	The SATCOL project is aimed at setting up a system to serve all national telecommunications needs. It will consist of one satellite in orbit, one back-up satellite, a command earth station and 170 fixed stations scattered throughout the country. The position of the satellite in geostationary orbit: 75.4° W. It currently uses a share of INTELSAT transponder capacity for its domestic system of eight non-standard earth stations.	The SATCOL project, as described under the "national system" heading.
Cuba	Cuba uses both the INTER-SPUTNIK and INTELSAT systems. It has one INTELSAT standard B earth station (Caribbean).		
Chile	Chile has used the INTELSAT system since 1968. ENTEL-CHILE, the signatory to the operating agreement, is the executing agency. It has two earth stations which are used for international communications: Longovilo I, standard A, 1 Longovilo II, standard A. Services: Telephone: 301 circuits in 1982 (DID) Telex Capacity: SCPC, 56 kb/s.	A domestic system, via INTELSAT, serves the southern part of the country: Non-standard Coihaique station. Non-standard Punta Arenas station. <u>Services:</u> Telephone Telex Television Longovilo III, standard A, is the command station for domestic service.	Through ENTEL, Chile forms part of the INMARSAT maritime communications system.

Table 3

## DOMESTIC SATELLITE SYSTEMS IN LATIN AMERICA

Country	Earth stations in place		Earth stations planned for late 1985	Leasing of INTELSAT transponders	Services	Domestic satellites
	Transmission and reception	Reception only				
Argentina	1(13 m) 30(11 m) 2(11 m) mobile 3(6.1 m) portable		3(11 m)	1-1/2 global <u>a/</u>	Telephone DAMA 1 television 1 radio	A proposal is being prepared
Brazil	1(15 m) 20(10m)	44(10 m)	18(6 m)	6 hemispheric <u>b/</u> 1 global	Telephones+ 2 television	2 Hughes HS376 24 band-C channels are being readied by Spar of Canada 2 launchings Ariane in 1985
Chile	3(11 m)		3(11 m)	1/2 global <u>c/</u>	Telephone	
Colombia	3(13 m) 14(11 m)		5(7.5 m) 2(13 m)	1/2 global <u>a/</u> 1/2 hemispheric	Telephone+ Television	SATCOL project under consideration
Mexico	7(11 m) 2 mobile	12(11 m) 23(7.5 m) 113(7.0 m) 14(5 m) 5(4.5 m) 2 portable	24(7.5 m) 86(7 m)	3 Spot <u>d/</u> 1 Galaxy <u>e/</u>	4 television+ telephone	2 HS376 under construction by Hughes 18 band-C channels 4 band-K channels 2 launchings on the Space Shuttle in 1985

Table 3 (Concl.)

Country	Earth stations in place		Earth stations planned for late 1985	Leasing of INTELSAT transponders	Services	Domestic satellites
	Transmission and reception	Reception only				
Peru	3(11 m)	3(6 m)		1-1/4 hemispheric <u>a/</u>	Telephone Television	
Venezuela	1(11 m)	1(9 m) 2(7 m)	21(7 m)	1 hemispheric <u>a/</u>	1 television	

Source: This table is based on a table contained in "Direct Broadcast Satellite Options for Latin America" by Elio Sion, Space Communications Group, Hughes Aircraft Company, El Segundo, California, United States, May 1984.

a/ INTELSAT V, F-4, built by FACC and launched in March 1982.

b/ INTELSAT IV A, F-2, built by Hughes and launched in January 1976.

c/ INTELSAT IV A, F-1, built by Hughes and launched in September 1975.

d/ INTELSAT IV, F-1, built by Hughes and launched in May 1975.

e/ Galaxy 1, operated by Hughes Communications, built by Hughes and launched in June 1983.

In connection with these last two uses of telecommunications satellites, those interested in a comprehensive discussion of the need to consider the use of such systems for the transfer of development-related information are referred to a document entitled "The Use of Satellite Communications for Information Transfer" (document PGI-82/WS/5), published by UNESCO as part of its general information programme.

Because of the relevance of the concepts discussed in that publication, selected paragraphs are quoted below.

In the section entitled "Nature and characteristics of the information required" (p. 6), it states:

"The requirements in terms of volume and of timely and fast transmission at a world-wide level would make the consideration of satellite facilities essential. The requirement for relevance in terms of the interests of specified user groups would seem to imply the need for feedback facilities, i.e., for two-way communication links. Two-way links would also be required if a network is supposed to function in a participatory manner in the sense that all participants function as both originators and receivers of information.

"The distinction between the various levels of information transfer is useful in defining the nature of the information required at each level, and thereby can help determine the communications facilities which are needed.

"a) At the policy or strategic level, developing countries will need information which enables them to assess possible alternative development strategies. This type of information transfer can only be organized with the aid of skilled and experienced teams who fully understand the technologies to be transferred and the local environment into which they are to be introduced.

"Although some information available in the industrialized world may be of value in this connection, the concept of technical co-operation among developing countries takes on particular importance for the transfer of information at the policy level and the transfer of technology. This concept is based on the recognition that:

"- Research and development in the industrialized countries is conducted according to policies and objectives which are often unrelated to the needs and circumstances of developing countries. Thus, 'there are areas and subjects in which relevant technical co-operation can only come from other developing countries: the problems involved do not exist in industrialized countries, nor do they dispose of the technical tools to tackle them'. (Kuwait Declaration, June 1977: Preparatory Consultation for United Nations Conference, Buenos Aires, 1978.)



"- A much greater range of technologies and experience than was previously supposed exists in developing countries. These technologies have not been widely available due to a series of biases such as price distortions and focussing on the sale of 'off-the-shelf' technology designed for industrialized countries' circumstances.

"The importance of this new perspective was reflected in the United Nations Conference on Technical Co-operation among Developing Countries (TCDC) held in Buenos Aires in 1978. As stated by Bradford Morse, Administrator of the United Nations Development Programme (UNDP) and Secretary-General of the Buenos Aires Conference, this new approach concerns 'the redrawing of the utilization map of communications and resources --both intellectual and material-- of our planet ... we are seeking to restore a balance, new means for peoples to listen to peoples, so that nations can choose in more genuine freedom what they can usefully select from other experiences'.

"Almost all the texts and statements on TCDC and related issues emphasize the communications and information aspects. 'The moment one relocates the starting point and uses the concept of 'selection' rather than 'transfer', the communications approach to building self-reliance and to evolving new techniques for technical co-operation becomes more clear, whether at the international level of TCDC or at the internal level of development planning and action within a country.' (Childers, 1977.)

"It is, therefore, significant that a number of the objectives adopted for the Buenos Aires Plan of Action for Promoting and Implementing Technical Co-operation among Developing Countries specifically mention this aspect. The recommendations of the Plan of Action included measures to strengthen national information systems and regional information systems and regional information networks for TCDC, to promote the exchange of development experiences and 'to encourage and intensify the collection, processing, analysis and dissemination at the global level of information on the capacities and needs of developing countries'. (Recommendation 26.)

"Thus one of the requirements implied in this approach is to supplement the current mainly North-South communication pattern with a South-South dimension. In practical terms satellite communication technology would because of its inherent flexibility and scope provide a major tool for this purpose."

In reference to a specific case of telecommunications satellite use (UNESCO document PGI-82/WS/5, p. 8), it states:

"However, one aspect requires attention since it directly concerns the use of satellite communication for development purposes. While it is generally recognized that information transfer at the operative level requires local action,

there are examples of successful use of satellite facilities for supplementary information purposes. The experiment carried out in India under the title of SITE (Satellite Instructional Television Experiment) provides a number of useful lessons in this context. In the SITE project an advanced satellite system was used for television transmissions to selected villages in a number of Indian States. The content of these television programmes, which were designed for different conditions in various parts of the country, mainly consisted of development-oriented messages including scientific and technical information. The results of the experiment and the subsequent follow-up activities warrant careful study." (See annex 1.)

Another section which is of interest in connection with the use of satellite telecommunications systems by all or some of the Latin American countries discusses the trends which have been observed in the technological development of these systems (UNESCO document PGI-82/WS/5, p. 26):

"It would appear to be more relevant to the present study to consider the base line communications satellite of the future which will be characterized by high power, multibeam antennas and switching of digital traffic at the satellite, rather than the satellite configurations typified by INTELSAT V.

"If such satellites are indeed to become available, the relatively low cost of earth stations, the possibility of locating such earth stations at or near user premises thus excluding the cost of terrestrial links, the possibility of providing an economical service directly to small, inaccessible communities and the low 'cost per bit' that will follow from the large capacity per satellite, will permit the introduction of services that at present are not considered cost-effective for satellite systems.

"Although transmission costs can be expected to continue a downward trend, the cost of establishing the space segment of new communication satellites will show the opposite tendency, due to the increased power, size and complexity of the satellite and the attendant increase in launch costs. Consequently, the satellite-based telecommunications facilities are likely to come within an affordable range for progressively smaller user communities (or rather user communities having fewer resources) while the increasing size, complexity and overall cost of a satellite system will dictate that the planning and implementation of such systems will remain the province of larger user communities, international and national agencies /or groups of countries such as the Latin American nations/. In other words, the technical advances leading to lower telecommunications transmission costs and potentially extending a wide variety of services to a larger user community, will not, per se, give the new users any direct influence on the design of the system, nor will they guarantee the availability of the facilities."

A final consideration with respect to satellite telecommunications and the needs of the Latin American countries is that the companies manufacturing this type of satellite are offering satellite communications systems with 12 or more transponders to each of the countries in the region. Inasmuch as these are profit-making enterprises, some of the reasons for doing this are obvious; another reason, however, is that there is no valid representative of the Latin American countries as a group with which an analysis of joint solutions could be undertaken. If only it were possible to establish a basic unit that could serve as a link among this group of countries in carrying out horizontal co-operation with respect to projects for utilizing space technology, they could then begin to find viable solutions whereby each country would benefit from the joint efforts of all.

#### Preliminary conclusions

Based on the above, the following preliminary conclusions can be reached:

1) Satellite telecommunications systems are used by the countries of the region for international communications via INTELSAT; some of the countries are already using them for internal communications as well (domestic systems, also via INTELSAT).

2) The national technical organizations operating these systems are experienced in their use.

3) Some of the Latin American countries' social and economic development needs have been identified, such as the need for communications links between remote areas and economic and cultural centres, tele-education, tele-conferences on an interactive basis, satellite-linked computer networks and data bases accessible via satellite.

4) Individual satellite telecommunications systems have been planned for a number of countries on a separate basis, but no plans have been developed for regional systems designed by the countries themselves which would meet the needs of the region or of a group of countries.

5) Telecommunications firms offer individual systems because there is no suitable representative for any group of countries with which group solutions could be studied.

6) Solutions based on individual satellite systems are only accessible to countries having the necessary economic resources; joint systems involving either all or some of the countries of the region appear to be a viable and justifiable large-scale investment which would meet a great many needs.

7) The reasons why these many similar needs have not been addressed on a joint basis may include all or some of the following:

a) A lack of knowledge about how modern communications satellites (as well as other satellite-based systems) can help to resolve development problems;

b) A lack of awareness of the similarity of the problems faced by the countries of the region and of the fact that, taken as a whole, they could justify the large investment required for a national system so long as it is financed on a joint basis;

c) Mistrust stemming from old or recent border disputes, the potential for a few countries to gain dominance over the rest, ideological differences among the governing groups in various countries, different theories concerning State security and misconceptions about the power of control gained by those handling the space segment of such an effort. There has been no opportunity to hold an open discussion on these subjects with a view to arriving at a consensus as to the basis on which development needs might be satisfied;

d) A lack of political will to undertake a joint effort involving a number of countries aimed at dealing with development problems.

8) One of the outcomes of the Latin American and Caribbean meeting of governmental experts on co-operation mechanisms in the field of outer space should be an agreement to entrust a group of telecommunications experts from the countries of the region with the task of designing one or more satellite communications systems to meet the needs of the countries of the region. The governments could then consider these concrete solutions and decide upon a specific proposal. In designing these systems, all their technical and economic aspects should be covered. The manner in which the necessary financing would be provided for this work should be agreed upon at the meeting of governmental experts.

9) In order to ensure the continuity of horizontal co-operation efforts in the field of outer space, there must be some point of reference which would afford at least a minimum of opportunities for the interconnection of these efforts. This function could be performed by a Latin American co-ordination office for space-related matters which would provide a meeting point for specific activities.

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Annex 1

ATS-6: Satellite Instructional Television Experiment (SITE)

This satellite, which is part of NASA's applied technology series, was the culmination of a decade of experimental research and development whose object was to engineer triaxially-stabilized geosynchronous satellites for relaying audio and video communications from a ground transmitter to a very large reception area. The ATS-6 weighs 1 400 kilogrammes, is 7.9 metres high when its panels are extended, and has a maximum width of 15.8 metres. Its antenna, which has a diameter of 9 metres, can be aimed with an accuracy of  $0.1^\circ$  of arc.

In May 1975, the ATS-6 was shifted from its position at  $94^\circ$  West Longitude, which it had reached only six and one-half hours after its launching on 30 May 1974. Guided by commands from earth, it moved east until reaching a position at  $31^\circ$  East Longitude over Kenya on 1 July 1975, where it was used in the Satellite Instructional Television Experiment (SITE) during a period of one year.

This experiment had been agreed upon by the Atomic Energy Department of the Government of India in a Memorandum of Agreement with the National Aeronautics and Space Administration (NASA) which was signed in September 1969.

The training objectives of the Indian Government included:

- 1) To contribute to the family planning programme;
- 2) To improve agricultural practices;
- 3) To contribute to national integration;
- 4) To contribute to adult education;
- 5) To contribute to teacher training;
- 6) To upgrade occupational skill; and
- 7) To improve health and hygiene.

The technical objectives were:

- 1) To test a satellite television broadcasting system for national development purposes;
- 2) To increase the capacity for designing, manufacturing, installing, operating and maintaining television broadcasting, reception and distribution facilities;
- 3) To study such subjects as:
  - a) The optimum density of television receivers; optimum distribution and programming;
  - b) Techniques for attracting television viewers and the corresponding organization; and
  - c) The problems involved in designing, preparing, presenting and transmitting programmes.

NASA's responsibilities were to plot out, orient, operate and monitor the performance of the ATS-6 during the year in which SITE was operating (August 1975-August 1976).

India's responsibilities, which were assumed by the Indian Space Research Organization (ISRO), covered the entire ground system, the preparation and transmission of television programmes and the evaluation of the technical and social aspects of the experiment.

The ATS-6 relayed the video portion and two audio subcarriers at 860 MHz to six clusters of 400 community receiving stations. The clusters were located in the states of Karnataka, Andhra-Pradesh, Madhya Pradesh, Orissa, Bihar and Rajasthan.

The signals relayed by the ATS-6 originated from the band-C transmitters at Ahmedabad and Delhi.

Responsibility for the production of television programmes was assigned to All India Radio (AIR) of the Ministry for Information and Broadcasting of India.

Ninety-minute morning programmes were broadcast six days a week. The were primarily intended for school children between 5 and 12 years of age and as a vehicle for training some 96 000 teachers. Evening programmes were broadcast for two and one-half hours, seven days a week; these were educational programmes aimed at the adult audience in villages.

Prior to the SITE experiment, television use in India was very limited. The first broadcasts, which were begun in Delhi in 1959 with the assistance of UNESCO, had a range of 24 kilometres and served selected schools and community centres. In 1971, a new transmitter was installed which increased broadcasting range to 60 kilometres. From that time on, progress was very slow. It was not until 1972 that another city (Bombay) received television service. This was due to the high cost of the imported technology involved and to a lack of awareness of television's power of persuasion and its attractiveness.

The decision to use television as a development tool was taken only after an exhaustive analysis of the options offered by the mass communication systems available in the late 1960s.

As Vikram Sarabhai, Chairman of the Atomic Energy Commission of India, said in "Television for Development": "In any developing country, one of the main ingredients of development is the dissemination of information: information on new fertilizers, seeds, insecticides, harvesting patterns, new technology and new discoveries in all fields, new products and services, new lifestyles, etc. The educational process is fundamentally related to the process of information dissemination/transfer. For the rapid and steady progress of developing countries, the pressing need to disseminate information to the masses is obvious".

Of all the mass communication media, television is the one which can have the greatest impact on people with little schooling.

Since India's progress between the 1970s and 1990s depends to a great extent on the development of rural areas, it is necessary to provide instruction for rural inhabitants and to enrich village life as rapidly as possible.

The television transmission system shown to be the most effective by an analysis of the available options, taking the time periods involved into consideration, was that which could be provided by the new ATS-6 type of satellite communications systems. The greater actual transmitting power which this system has because of its large-diameter antenna made it possible to reduce the cost of community earth stations, which were the most expensive segment of the ground system to be financed by the Indian Government.

This one-year experiment was highly successful and the results it provided would have taken four generations of effort to produce by conventional methods.

The SITE experiment has been continued using Indian satellites such as INSAT.

Other very valuable experiments concerning the use of ATS-type telecommunications satellites for educational applications are:

PEACESAT: Pan-Pacific Education and Communication  
Experiment by Satellite

In 1971 a consortium of users started the first international health and education network using the ATS-1. The Project is known as PEACESAT (Pan-Pacific Education and Communication Experiment by Satellite) and links up educational institutions in 12 countries. Small, inexpensive earth terminals, which are co-ordinated in Honolulu, Hawaii, are used. Locally-owned terminals operate in Honiara, Solomon Islands; Rarotonga, Cook Islands; Suva, Fiji; Tarawa, Gilbert Islands; Honolulu and Maui, Hawaii; Nuku'alofa, in Tonga; Numea, New Caledonia; Port Vila, New Hebrides; Wellington, New Zealand; Island Nine; Lae and Port Moresby in Papua, New Guinea; Saipan, the Trust Territory of the Pacific Islands; Santa Cruz, California; Pago Pago, Samoa; Apia, off Eastern Australia and Sidney, Australia. Many programmes concerning health, nutrition, education and training are broadcast.

ATS-6 use in the United States

As part of the large-scale use of educational, medical and other television programmes made possible by the ATS-6, an exercise was conducted during its first year in orbit in which the teachers in 600 elementary schools in eight Appalachian states used it for undergraduate studies. The educational programmes were also rebroadcast to high school students in the Rocky Mountain states and to students and teachers in Alaska.

PROJECT SATELLITE of the University of the West Indies

PROJECT SATELLITE was carried out by the University of the West Indies (UWI), a regional university with 8 040 students as of 1978, which serves a wide area of English-speaking territories in the Caribbean. With the co-operation of NASA and USAID, it conducted a very valuable experiment involving the audiovisual transmission of lectures to the three main campuses of the University, which are located in Jamaica, Barbados and Trinidad.

The University of the West Indies carried out an experiment in the utilization of communications satellites in order to learn more about the possible ways in which this technology could help to solve a number of problems resulting from the fact that this university has various schools and other units in the Caribbean that are separated from the main campus in Jamaica by considerable distances.

The UWI is an international institution of higher learning which serves 15 English-speaking territories in the Caribbean: the independent nations of Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Jamaica, St. Christopher and Nevis, St. Lucia, St. Vincent and the Grenadines and Trinidad and Tobago, as well as Anguilla, the British Virgin Islands, the Caiman Islands and Montserrat, which have some form of association with the United Kingdom of Great Britain and Northern Ireland.

Less than 1% of this area's 4.5 million inhabitants are university graduates. The demand for education and training is on the rise.

The main campuses of the university are Mona in Jamaica, St. Augustine in Trinidad and Cave Hill in Barbados. It also has many autonomous or semi-autonomous units.

During the academic year 1977/1978, enrollment totalled 8 040 students.

The PROJECT SATELLITE experiment involved establishing two-way video and audio links among the three main campuses using the ATS-6 satellite for video transmission and the ATS-3 for audio transmission.

The objectives of this project were to determine:

- 1) The feasibility of broadcasting extension programmes to the countries and territories of the region served by the University;
- 2) The extent of acceptance by users and their enthusiasm with respect to this technology;
- 3) The usefulness of broadcasting courses on television via satellite;
- 4) The value of transmitting lectures and consultations via satellite as an effective means of co-ordinating teaching, research and administrative activities.

Between 16 January and 10 March 1978, three weekly 90-minute programmes were broadcast, including two seminars of two and one-half days in duration.

The results were as follows:

- 1) Community outreach efforts accounted for 51% of programming time and were highly successful;
- 2) There was a great deal of interest in the project and in assisting in its execution both within and outside the University;
- 3) Seven lectures lasting a total of 6 hours do not provide an adequate basis for assessing the system's usefulness because the students were not tested on the knowledge they had acquired. Students and lecturers did, however, express their interest in this portion of the programme and regretted the fact that so little time had been devoted to it;
- 4) The lecture broadcasts proved to be a revelation, inasmuch as they were remarkably effective in serving the purposes for which they were designed.

An agreement was signed on 18 May 1982 between the University of the West Indies and the Office of Science and Technology of the United States Agency for International Development (AID). Under this agreement, the University of the West Indies is to serve as the headquarters for one of the pilot projects for AID's Rural Satellite Programme and will also receive technical assistance and training in the development of methods for optimizing the use of interactive educational systems and for university extension activities. It is expected that this two-year pilot project will permit lectures to be broadcast via an operational satellite system to be established for use by the University and development agencies in the region.

Annex 2

REMOTE SENSING IN SOME DEVELOPING COUNTRIES: TABULATED SUMMARY BASED  
ON REPORTS SUBMITTED TO THE INTERREGIONAL EXPERT MEETING ON  
THE USE OF SATELLITE IMAGING RADAR AND THEMATIC MAPPING  
DATA IN NATURAL RESOURCE DEVELOPMENT  
(WEST BERLIN, 21 NOVEMBER TO  
4 DECEMBER 1984)

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Country: BOLIVIA; 1 098 581 km<sup>2</sup>.  
5 916 000 inhabitants  
(1982 estimate)

Data source: Report by René Valenzuela, Executive Director of the Centre for Remote Sensing Research and Applications, Geological Service of Bolivia.

Remote sensing data: LANDSAT.

Origin of remote sensing data: NASA, INPE (Brazil)

Institutions: Centre for Remote Sensing Research and Applications (CIASER), a unit of the Geological Service of Bolivia. (CIASER is continuing the ERTS Programme of GEOBOL.)

Applications:

- . 1920s: Standard Oil Company takes aerial photographs of the sub-Andean mountain region in south-eastern Bolivia at a scale of 1:80 000. Photomosaics are used as a guide for oil exploration.
- . 1950s: The Military Geographical Institute (IGM), aided by the Inter-American Geodetic Service, obtains aerial photographs of the Altiplano for use in drawing topographic maps at a scale of 1:50 000.
- . 1960s: Yacimientos Petrolíferos Fiscales Bolivianos (YPFB), a State company, decides to take aerial photographs and sets up its own remote sensing laboratory.
- . 1960s: The Geological Service of Bolivia is founded for the purpose of producing a geological map of the country using existing aerial photographs.
- . 1970s: The Bolivian Government is invited to participate in the LANDSAT experimental programme. GEOBOL selects areas in which to demonstrate its feasibility in the fields of mapping, geology, geomorphology, soil sciences and forestry. NASA provides 65 LANDSAT shots.

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BOLIVIA (Cont.)

- . 1977: INPE (Brazil) supplies operational LANDSAT data.
- . 1981-1983: The ERTS programme is put on hold due to political changes.
- . 1983: The ERTS programme is reactivated under the name of CIASER.

Mapping: Due to the nature of the LANDSAT images, their wide coverage, multispectrality and repetitivity, they prove to be very useful in planimetric mapping.

- . In 1973, IGM published a new administrative map at a scale of 1:1 000 000, updating the data using LANDSAT imagery.

Only 45% of the territory to the south of 16° South Latitude is covered by maps at scales of 1:50 000 and 1:250 000. A total of 28 LANDSAT images obtained between 1972 and 1976 were therefore used to prepare maps of the northern part of the country for the 1976 housing and population census.

The IGM used geometrically-corrected LANDSAT images in preparing the planimetric map published under the name of "Salar de Coipasa" at a scale of 1:500 000.

Geology: The photographic geological work initiated in 1958 by Standard Oil was followed up by YPFB and later by GEOBOL, which published a geological map covering 20% of the territory in 1960.

In 1976, an experiment was conducted in the use of infra-red photography in the north-eastern tropical region to enhance images of the wetlands and to obtain information on the drainage control function performed by subsoil geological formations.

The experimental use of LANDSAT imagery yielded good results and the company was put in charge of producing the First Geologic Map of Bolivia at a scale of 1:1 000 000 using the information accumulated by GEOBOL and YPFB.

Mining: LANDSAT images have been used in determining structural, geomorphic and tonal anomalies in order to locate potential areas of mineralization.

Contour lines have indicated the location of mineralized intrusions which serve as important markers in defining exploration zones.

LANDSAT images are the only ones in which contour lines have been detected running in a transverse direction to the structural system of Andean folds; they may prove to radiate out from the Arica projection or may run from east to west.

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BOLIVIA (Conc.)

A paper has been published under the title of "Mineralización de los Andes Bolivianos en relación con la placa de Nazca", which includes maps of contour lines and intrusive bodies, mineralized strips and the metalogenesis of the Bolivian Andes in relation to the Nazca plate.

- Contrast- or band-quotient-enhanced imagery was used to locate hydrothermal anomalies and to study the surface of salt deposits. In the latter connection, the Uyuni salt deposit is of particular interest; LANDSAT data were used to locate large concentrations of potassium and lithium salts at that site.

Land use: Following three years of research, the first land-use map based on LANDSAT imagery was published in 1978.

Digital multispectral analysis: Since most LANDSAT data are on CCT's computer-compatible tapes experience was gained in conducting digital analyses of soil, geology, plant cover and land use.

The first programme dealing with this subject was developed at the Laboratory for Applied Remote Sensing (LARS) at Perdue University. The results were published in a paper on the digital processing of multispectral data on the drainage area studied under the experimental project.



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Country: CHILE: 2 006 626 km<sup>2</sup> (includes 1 250 000 km<sup>2</sup> in Antarctica)  
11 617 000 inhabitants (1983 estimate)

Remote sensing data: LANDSAT/MSS  
NOAA/AVHRR  
Nimbus/CZCS

Origin of remote sensing data: United States, Brazil, Argentina  
CEE/University of Chile  
CEE/University of Chile

Institutions: University of Chile, School of Physical Sciences and Mathematics, Space Studies Centre (CEE) (Division of NASA). The CEE is an executing agency for contracts between NASA and the University of Chile concerning the operation of the Santiago Tracking Station, which is part of NASA's STDN Network; it is conducting a programme on space technology applications in the country.

Chilean Airforce, Aerial Photogrammetric Service (SAF)

Applications/training:

History:

Airborne remote sensing has been used in Chile since the SAF commenced operations. Satellite remote sensing was first undertaken at the Space Studies Centre (a division of NASA) in 1974.

The CEE's space technology applications programme includes the automatic environmental collection system via the geostationary operational environmental satellite (GOES) (DCS), LANDSAT data applications, the experimental system for direct access to LANDSAT's MSS (multi-spectral scanner), direct reception of NOAA/AVHRR and Nimbus/CZCS data, a GOES/VISSR/WEFAX data receiving station, the development of equipment for the digital analysis of satellite imagery.

In a number of the above systems, the equipment of the Tracking Station has been used when this could be done without interfering with NASA missions. The experience of CEE staff and the University's support have made it possible to design and construct electronic equipment which, when integrated with the Station's systems, have allowed direct access to and the processing of satellite data.

GOES/DCS system: Hydrometeorological data are received at a dozen collection platforms in remote areas not accessible to State agencies (General Water Directorate, the Chilean Antarctic Institute), State companies (Empresa Nacional de Electricidad) and private companies (Compañía Minera la Disputada de Las Condes). Direct access to GOES satellites is governed by an agreement between NOAA/NESS and the University of Chile. The reception station was designed and built by CEE personnel.

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CHILE (Cont.)

LANDSAT data applications:

Since 1977, projects have been conducted on the applications of LANDSAT imagery in various earth science disciplines.

Some of these projects are described below:

1. The MINVU Project (1978). Urban studies applications of LANDSAT imagery. On the basis of enlarged photographs of 12 cities in the central region of Chile, it was concluded that the LANDSAT MSS was useful for visualizing the growth of cities and for distinguishing urban structural categories in large cities. It is hoped that a better TM spatial resolution can be achieved for other types of study.
2. The ALUS Project (1979). Land use applications of LANDSAT imagery. The crops in two communities in the central valley were digitally classified into fruit crops, vineyards, grain crops and small farms growing field crops. The areas estimated were compared with existing statistics, and excellent results were obtained for vineyards and grain crops.
3. The ALFO Project (1980). Forestry applications of LANDSAT imagery. Fifteen parcels belonging to CELCO, a forestry company, were subjected to a multi-temporal analysis in order to detect changes (e.g., farming, fires and the expansion of plantings). This was the first time work was conducted at a scale of 1:20 000.
4. The IRS Project (1981-1983). A crop-identification study using multi-temporal visual analyses. The project's scope was expanded from 1 to 12 communities between 1981 and 1983.
5. The TEMFORD Project (1981). Tele-detection in dynamic forestry management. A vegetation coverage study was conducted over an area of 780 000 hectares, and 30 different subject-area categories were distinguished. The status of the area in 1975 and in 1981 was compared. As part of the EXYR Project, this information was later updated to 1983.
6. The Camanchaca Project (1984). A study concerning the use of coastal fog as a water source. LANDSAT images have been used to determine the best areas in which to install fog collectors. The volume of water collected and meteorological conditions are simultaneously measured using a satellite data collection platform (DCP).
7. The ENDESA Project (1984). Monitoring of the area affected by the Colbún-Machicura hydroelectric plants. The study's purpose is to analyse the environmental impact these plants will have when construction is completed and they enter into operation. The reference map was completed in 1984 and will be updated each year to reflect the changes that have occurred.

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CHILE (Cont.)

Direct access systems (LANDSAT, NOAA, NIMBUS, GOES/VISSR/WEFAX satellites)

The Tracking Station has receiving equipment (antennas, low-noise pre-amplifiers, converters, receptors) and data processors. The publication of information on units designed and constructed, in a number of cases, as part of the thesis work done by students graduating from the School of Engineering of the University of Chile under the direction of CEE engineers has made it possible to set up direct access and imagery processing systems for LANDSAT, AVHRR, CZCS, VISSR and WEFAX.

An independent station for receiving and analysing meteorological imagery

The experience that has been gained has recently led to the design and construction of a small independent station for receiving WEFAX (weather facsimile) and infra-red VISSR (visible and infra-red spin-scan radiometer), images, which can be viewed on-screen and can be enhanced in various ways useful to meteorologists. This station can be easily transported and is intended to serve national institutions.

The CEE has designed and built a system for digital image analysis using microprocessing technology. The programmes have also been developed locally. This unit makes it possible to work with LANDSAT MSS and TM, AVHRR, VISSR and CZCS imagery. All the usual enhancement techniques used in imagery work are available to the user of this equipment. Only a film writer need be added.

Other CEE activities

The CEE technology applications programme also includes search and rescue satellite-aided tracking (the SARSAT project), which was begun in 1984, as well as the exploration of possible activities in the field of satellite telecommunications, which has already resulted in the construction of antennas for the reception of television signals from geosynchronous satellites.

In view of the scheduled conclusion of NASA's satellite tracking activities and the projected transfer of NASA's STDN Station facilities to the University of Chile, tracking and telemetry services are to be offered to other foreign space agencies.

It is hoped that all these activities will permit the CEE to remain in operation after 1986.

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CHILE (Concl.)

Training in remote sensing

There are still no postgraduate university programmes in remote sensing in Chile. A relatively extensive treatment of the use of these techniques is offered only in some undergraduate programmes. The lack of laboratories is one of the main problems.

With the assistance of FAO, in June 1983 the CEE organized a training seminar on the application of remote sensing techniques to agriculture, forestry, geology and coastal resources. In 1984, practical training mini-courses were offered to approximately 80 professionals in various disciplines.

It is estimated that there are some 200 professionals in the country with varying degrees of know-how and experience in remote sensing techniques and that approximately 100 of them have actually worked with remote sensing applications.

Other organizations conducting remote sensing work

- The Aerophotogrammetric Service (SAF) of the Chilean Air Force has all the equipment needed to take aerial photographs, as well as a Log E digital analysis system for working with LANDSAT imagery.

- The Institute of Natural Resources (IREN-CORFO) is the national organization responsible for maintaining a data base on the country's natural resources. It primarily uses aerial photographs. It has only used LANDSAT images on an experimental basis.

- The National Forestry Corporation (CONAF) is expanding its professional capacity as regards the use of remote sensing data in studies on the country's forestry resources, environmental deterioration and particularly in studies concerning national river basins. It is working with the CEE on LANDSAT data applications.

- The National Copper Corporation (CODELCO) has used LANDSAT MSS data in some of its work. It has professionals on its staff who are trained in these techniques.

- Other Chilean universities have small research groups which use satellite remote sensing techniques (the University of Santiago and the Federico Santa María University).

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Country: CHINA: 9 596 916 km<sup>2</sup>

1 020 673 000 inhabitants

A summary of the paper presented by Mr. He Changchui

Remote sensing data:

Origin of remote sensing data:

Institutions:

The National Commission on Science and Technology

- . Formulates plans, policies and strategies for developing remote sensing;
- . Organizes, co-ordinates and manages remote sensing projects;
- . In 1981, the Council of State approved the establishment of a National Remote Sensing Centre, whose work consists of:
  - Formulating policies and plans for the development of remote sensing;
  - Co-ordinating scientific and technological efforts in the field of remote sensing;
  - To organize key projects of national importance;
  - To promote international exchange and co-operation;
  - To carry out remote sensing research and training activities;
  - To provide data services and to answer technical queries.

Many organizations and centres engaged in applying remote sensing have been established, including the Ministry of Geology and Mineral Resources and other bodies in the oil industry, in agriculture, forestry, water resources and electricity.

Applications:

- The National Inventory of Land Resources, which was carried out by 100 specialists from the Prospecting and Mapping Office, the Ministry of Forestry and the Ministry of Agriculture, was completed in only two years. A total of 560 LANDSAT shots covering the entire country were used. Thirty different categories of land use were identified. A land-use map at a scale of 1:2 000 000 covering the entire country was also completed using optical rectification techniques. Provincial land-use maps at a scale of 1: 500 000 were also prepared. The cost of the project was 0.30 yuan per km<sup>2</sup> (the exchange rate is 2.07 yuan per US dollar.)

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CHINA (Cont.)

- An integrated survey for agricultural development, covering an area of 156 000 km<sup>2</sup> in Shang xi Province, was carried out in a little over one year. Multispectral LANDSAT data were used to produce 17 types of thematic maps, including geological, geomorphological and soil maps, as well as maps for agricultural and regional planning.
- Monitoring the environment: In combination with LANDSAT data, aerial remote sensing has been used in environmental experiments in Beijing, Tianjing and other cities.

Using multi-band photography, infra-red detectors, infra-red colour photography and conventional colour photography, studies were conducted on urban pollution, the effect of heat spots, traffic flow and urban soil use.

- Geological studies and mineral exploration: A geological map at a scale of 1:1 500 000 of the province of the Qinghai-Xizang plateau and a map of China's linear formations at a scale of 1:6 000 000 were completed. LANDSAT MSS data (in colour) and aerial photographs were used to detect geological faults and dislocations that would affect the placement of railway tracks. These techniques have been particularly useful in China's mountainous south-eastern region. While studying the applications for digital processing of MSS data in the Chaidamu basin, a zone with dense sand cover, a geological formation canted towards the west was discovered which gives a new picture of this natural gas- and oil-bearing basin's geological structure.
- Applications in ecological studies: Aerial remote sensing satellite data has been used to conduct forestry and rangeland inventories. Remote sensing is also being employed in mapping surveys of Inner Mongolia's grasslands.
- The development of local capacities: The various spheres involved in basic research are: spectral instrumentation, spectral measurements, data processing, image-acquisition mechanisms, the selection of spectral bands, etc. For example, ten different types of long wave (between 0.4 and 1.1  $\mu\text{m}$ ) spectrometers have been developed during the past ten years.

Emphasis has been placed on instrument calibration, methods of measurement, the standardization of data processing, etc.

The National Remote Sensing Centre intends to establish a spectral data bank on ground subjects for use in the systematic management of the spectral information which has been gathered.

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CHINA (Cont.)

The Chinese Academy has set up a remote sensing simulation laboratory in which any sample of up to one ton can be measured under solar conditions that can be varied at will and other conditions.

The development of remote sensors: Sensors have been developed in the visible, near infra-red, thermal infra-red and microwave spectrums. Multi-band cameras with a format of 70 x 70 mm, large-format cameras, 9-band spectral scanners, two-channel radiometers in the visible and infra-red spectrums, one-, two- and six-channel infra-red scanners and an 11-channel multi-spectral scanner that uses HgCdTa and InSb detectors have also been developed. A CCD scanner has recently been tested which uses a linear configuration of 1 024 detectors. Airborne microwave radiometers of 1.25/3/10 cm have also been developed.

In the field of active sensors, an experimental band X lateral-view radar system has been developed which provides images with a resolution of 10-12m and which takes strips measuring 10 km in width.

Image processing: A variety of techniques (optical, photographic, photoelectric and digital processing) have been developed.

A number of optical processing systems for making different types of modifications, enhancing, filtering, etc., have been developed. A number of instruments have been devised in the last few years for developing digital image processors using mainly Chinese resources. Since 1980, an effort has been made to promote the design of a digital image processing system based on the Chinese DJS-186 computer.

The use of microcomputers has also received attention. A system based on the Chinese BCM-38 bit microprocessor is capable of processing an image of 2 048 x 2 048 times 8 bits in 13 minutes; during that time span, the following functions are performed: the reading of the data, geometric correction, projection transformation, enhancement, differential processing, pseudo-tridimensional display, etc.

Image processing techniques lag behind sensor capabilities, and the necessary equipment must therefore be imported. At present, there are approximately 20 imported systems in use from I<sup>2</sup>S and DIPIX.

Objectives as regards the development of remote sensing science and technology

The long-term plan of the National Commission on Science and Technology of China includes:

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CHINA (Concl.)

- to move beyond the experimental activities currently being conducted and to undertake operational exercises in order to help build the national economy;
- to develop quantitative analysis techniques to take the place of the present qualitative studies;
- to stress dynamic monitoring and analytical capacity;
- to utilize computer techniques, information systems and the earth sciences on an integral basis in planning, management and decision-making relating to resource development and environmental monitoring.

In pursuit of these objectives, an even greater effort is to be made to promote the establishment of a LANDSAT station and the development of its capacity to receive SPOT (experimental earth observation system) data as well. A complete airborne system equipped with various sensors (including synthetic aperture radar, which is useful for the tropical regions where there is heavy cloud cover) is needed.

A digital natural resource data bank is to be set up. As a first step, a DTM (digitalized topographic map) at a scale of 1:250 000 is to be completed over a three-year period.

Finally, the country will open its doors to the outside world in order to strengthen its relations with scientists throughout the world and to promote bilateral or multilateral co-operation in the fields of remote sensors, data acquisition, data processing and applications, and training.



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Country: ECUADOR: 275 030 km<sup>2</sup>  
8 053 280 inhabitants (1982 estimate)  
Report by David Logacho. CLIRSEN

Remote sensing data: LANDSAT: Only the LANDSAT 1, 2 and 3 MSS of selected dates cover a portion of the territory. LANDSAT IV or V MSS or TM data on Ecuadorian territory are not available.  
NOAA: Surface ocean temperature  
Aerial photography Radar: (SAR) Band X

Origin of the data: LANDSAT: Recorder of LANDSAT 1, 2 and 3  
Ecuador's territory is not covered by any LANDSAT earth station  
NOAA: the Lanion Centre in France  
Black and white infra-red photos. The Ecuadorian Military Geographical Institute  
1) (October to December 1982)  
Radar: (Aeroservice) Caravelle flying at 1 200 m  
Resolution: 10 m. Area covered: 135 561 km<sup>2</sup> (54 000 km<sup>2</sup> - stereoscopic radar).  
2) SIR-A: 25 m resolution  
Geophysics: Magnetometric survey of Ecuador's entire territory for use in mining and oil exploration  
Gravimetric data obtained from surveys conducted by oil companies

Institutions: CLIRSEN: (Centre for Remote-Sensor Integrated Natural Resource Surveys):

- Integrated survey of renewable and non-renewable resources
- Collaborates on the preparation of cartographic and thematic maps
- Plans, co-ordinates, directs, executes and monitors all of Ecuador's remote sensing activities.

Applications:

CLIRSEN Projects:

- 1) Pilot project on natural resource assessment: The development of a methodology for using and handling remote sensor images and data and for assessing the agricultural, forestry, geological and water resources in the south-central Amazon region of Ecuador (43 000 km<sup>2</sup> covered).

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ECUADOR (Cont.)

- 2) A forestry survey of the Amazon region of Ecuador, covering 3 500 000 ha, demonstrated the efficiency of remote sensing techniques.
- 3) Remote sensors in agriculture: The inspection and assessment of major crops in the highlands and coastal zones.
- 4) Oceanographic research: Technical support was provided by the University of Delaware for this project on applying and making known remote sensing techniques used in oceanographic studies and in the analysis of coastal resources as well as physical, chemical, biological and meteorological phenomena. It included a survey of mangrove swamps and shrimp-bearing lakes.
- 5) Changes in land use in the northern part of Ecuador's Amazon region. LANDSAT and aerial photography were used.

Projects conducted by other agencies:

- 1) With the Ecuadorian Institute for Water Resources: The selection of dam sites in the Cañar, Paute and Jubones river basins.
- 2) With the National Institute for the Settlement of the Amazon Region: Research concerning natural resources in the central and southern Amazon region.
- 3) With the National Energy Institute: The geological interpretation of the Cuenca territory for use in research on geothermal energy.
- 4) With the National Polytechnic: Research on the ecology of the Amazon region.
- 5) With the Ministry of Agriculture: An inventory of Ecuador's natural forest resources.
- 6) With the Ecuadorian Atomic Energy Commission: Research on radioactive materials.
- 7) With the National Institute of Statistics: National agrarian statistics.
- 8) Centre for the Economic Reconversion of Azuay, Cañar and Morona Santiago (CREA): A survey conducted via radar and geological, geomorphological, forestry and hydrological thematic maps.

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ECUADOR (Concl.)

Training:

CLIRSEN plants to establish a training centre which will pursue the following objectives:

- The transfer of remote sensing technology to Ecuadorian professionals
- The accumulation of experience in various fields of research
- The dissemination of information on the use of remote-sensing imagery and other data.

Problems/Future Projects

- 1) CLIRSEN/IDB agreement: A master plan for delineating policies to govern the implementation of a geo-codified information system: 24 short- and medium-term projects in the fields of hydrology, forestry, oceanography, geology, agriculture, geography and soil sciences.
- 2) Data bank: A geo-codified information system is to be established for the use of State and private institutions.
- 3) The need for prompt access to remote sensing satellite data will not be met until Ecuador has its own direct-access station satellites.

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Country: INDIA: 3 287 590 km<sup>2</sup>

711 664 000 inhabitants (1982 estimate).

A summary of the paper entitled "A Decade of Remote Sensing in India - Some Salient Results", by Y. S. Rajan and V. R. Rao, which was presented at the Fourth Plenary Meeting of the Society of Latin American Remote Sensing Experts (SELPER), held in Santiago on 12-15 November 1984. Earth Observation Program Office, ISRO Headquarters, Canvery Bhavan, Kempegowda Road, Bangalore 560 009, INDIA.

Institution: Indian Space Research Organization (ISRO).  
Earth Observation Program Office.

### Applications

India's space programme was begun in the early 1960s by the Indian Committee for Space Research (NCOSPAR).

The current programme has two objectives: satellite communications and the management of natural resources using remote sensing.

Remote sensing was introduced in 1970 as part of a series of experiments to detect diseases in coconut plantations using airborne sensors.

Visual interpretation mainly of aerial photographs, was initially used.

An example: Is provided by the ARISE project on Anantapur in Andhra Pradesh, in which scientists from the ISRO and the Indian Council for Agricultural Research (ICAR) participated. Spectral bands and films very similar to those of the LANDSAT MSS were used. As a result of this project, it was determined that surface features can be satisfactorily identified from images at a scale of 1:30 000. All the main crops were identified and an inventory of them was prepared.

A number of projects were conducted using LANDSAT and NOAA satellite data as well; the fields in which they were applied included geology, geomorphology, hidrogeology, soil matching, hydrology, snow and flood mapping, sedimentation analyses, plant cover, mapping, etc.

Digital interpretation techniques were not used until 1978.

In 1975, the National Remote Sensing Agency (NRSA) was founded in Hyderabad to meet operational needs in connection with airborne sensors, the reception and transmission of satellite data, the preparation of surveys and the provision of advisory services to users. Its own LANDSAT direct access station began operations in 1979; this made it possible for the ISRO Space Applications Centre (SAC) to start using digital interpretation techniques and for a few users to begin to use SAC and NRSA facilities.

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## INDIA (Cont.)

SAC conducted experiments, some of them in co-operation with users, to determine what features India's future remote sensing satellites should have. They covered a number of applications: agricultural, soil, water, coastal and marine resources, forestry resources, land use, etc.

### Agricultural applications and soil studies

With the help of visual interpretation techniques, the soil in various regions was studied; this included an analysis of the possibility of irrigating drought-prone regions such as Karnataka, in southern India. The physiographic limits of aerial photographs were correlated with satellite images. It was determined that soil subgroups could be delineated and even matched using LANDSAT images and limited field data. The salinity of soil at two different levels could be separated out through the digital analysis of the data in an M-DAS system. Soil degradation was studied by the All Indian Soil and Land Use Survey (AISLUS), which led to the preparation of thematic maps; with the aid of computers, three levels of erosion were differentiated in granitic zones. The maps obtained from the analysis of LANDSAT data and aerial photo-interpretation (API) were compared with the maps prepared using conventional techniques. In general, the maps based on satellite data were more detailed and could be prepared in one-tenth the time needed to produce maps by conventional means (9 hours versus 90 hours, respectively, for an area of 180 km<sup>2</sup>).

Little study has been devoted to agricultural yields, partly because LANDSAT's MSS resolution is not sufficient for studying the small plots and mixed crops of Indian agriculture.

A 1981 study in the Mandya district in Karnataka produced results while also pointing up a number of problems.

At the Seminar on Crop Growth Conditions and Remote Sensing, which was organized by ISRO and ICAR in June 1984, 12 papers were presented on the use of remote sensing techniques to assess water and nutrients, crop growth, soil humidity, the radiation intercepted by vegetation, evapotranspiration, the production and yields of dry material and disease detection.

### Applications relating to forestry and plant cover

Indian scientists have used LANDSAT imagery and aerial photographs to arrive at a precise estimate of the extent of plant cover in the country, since this information had previously not been available. A broad classification shown on a ten-subject map demonstrated the usefulness of the technique and, by presenting the corresponding data in a single synoptic view, drew attention to the amount of land that has been damaged by crop shifts.

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## INDIA (Cont.)

The country's forests were recently mapped in a project which was completed in only six months and at a very low cost. It was found that between 1972-1975 and 1980-1982, the forest area decreased by 2.79%, most of this being in closed forests.

### Applications relating to water resources

A few studies have been conducted on the crucial issue of the supply of water for drinking purposes, irrigation and industrial use, as well as maps on the location of snows and possible sources of ground water.

### The location of ground water

This is reportedly a successful application which is at a semi-operational stage. The visual interpretation of LANDSAT images and aerial photographs reduces the area for explorations, thus cutting search time down to something between 1/10 and 1/30 of the time required using conventional techniques. For example, the Central Water Commission reported that high-yield wells could be drilled in the Vedavati river basin, their placement being determined solely by means of photo-interpretation and remote sensing techniques.

Another example is provided by the Rajasthan desert, where the use of multi-band images can be a reliable tool for finding abandoned or buried water courses and for obtaining a synoptic picture of the locations of water.

### Surface water resources

Aerial photographs and LANDSAT images have been used in surveying water deposits, planning drainage, managing water resource and monitoring water sedimentation and pollution. Quantitative estimates of the water supply in tanks and deposits have been prepared.

### Studies of snow run-off

A model was developed on the basis of the percentage of area covered with snow in the Sutlej basin, which was calculated using NOAA images taken each April from 1975 to 1978 and measurements of snow run-off in Sutlej (between April and June) during those same years. Predictions based on this model differed from the real values by only 6%. Subsequent improvements have reduced the model's margin of error to 5%.

### Applications relating to flood charts

A few studies have been done on variations in the course of the Kosi River; there are also charts on flooding in Kosi-Ganga and on the Sahibi River near Delhi. Due to the low repetitiveness of the LANDSAT images, such studies cannot be used for daily flood monitoring, but they have permitted a good assessment to be made of the areas affected.

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INDIA (Cont.)

Geological applications

Indian geologists have carried out extensive studies using LANDSAT and airborne remote sensing techniques. Despite certain limitations, these studies indicate that such techniques are valuable aids in preparing regional geological and geomorphological maps and in correlating large-scale geological features and structures in areas far removed from one another, as well as in delineating areas of detailed work in mineral-rich belts using aerial and field methods. The two limitations of satellite data are their spatial and spectral resolution and the fact that they are not stereoscopic.

Marine and coastal applications

The SAC has analysed the coastal environment in the Gulf of Khambat, using LANDSAT images to study sediments, surface currents, changes in the beaches and coastal morphology. The Saurashtra coasts and the ecosystems of the Gulf of Kuch have also been studied.

Multi-spectral, multi-stage LANDSAT data have been used to study fisheries in the vicinity of the Karwar and Cochin coasts.

Radiometric data supplied by the Indian Bhaskara satellites have been used in studying ocean-surface temperatures and winds.

Environmental applications

India is particularly interested in applying these techniques to environmental monitoring as part of its effort to achieve more rapid development while preventing environmental degradation as much as possible; remote sensing appears to be an effective and timely environmental monitoring technique.

Archeological applications

Indian scientists used LANDSAT images to trace the paleo-channels of the Sutlej, Yamuna and Saraswati rivers in an effort to solve the mystery of the "lost" Saraswati discussed in ancient Indian literature. The results indicate that the Sutlej previously flowed towards the Chaggar, whose bed can be traced up to Marot to the west. It is likely that the Yamuna also flowed towards the Chaggar. Scientists have concluded that the Chaggar was part of a large river which was known as the Saraswati in ancient times.

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INDIA (Concl.)

The present status of remote sensing applications

Remote sensing is growing rapidly in India and it is estimated that there are over 50 institutions and 1 000 scientists familiar with remote sensing techniques.



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Country: INDONESIA: 1 902 345 km<sup>2</sup>  
153 032 000 inhabitants (1982)  
3 000 islands

Data source: Report by Prof. Jacob Rais, Chairman of the National  
Surveying and Mapping Agency (BAKOSURTANAL)

Remote sensing data: Satellites: LANDSAT  
NOAA  
GMS

Aerial photography: IR  
Panchromatic

Origin of remote sensing data:

LANDSAT: The country's own station, which began operations  
in 1984, covers the western part of the country.  
Operated by LAPAN.  
The eastern part of the country is covered by the LANDSAT  
Australian Station  
GMS: Japan  
NOAA: United States

Institutions:

- 1) A national programme administered by the National Surveying  
and Mapping Agency (BAKOSURTANAL)
- 2) National Aeronautics and Space Institute (LAPAN)
- 3) A number of ministries
- 4) Two universities offer courses in digital image analysis
- 5) Research institutions
- 6) The private sector

Applications, training, problems: Remote sensing provides information for:

- Planning
  - Natural resources exploitation and management
  - The programme on internal migration
  - Environmental monitoring
- 1) Land-use maps
  - 2) Geological and geomorphological maps
  - 3) An inventory and maps of the sago palm
  - 4) Land restoration and resource management
  - 5) A survey of critical land areas
  - 6) A survey of mangrove swamps and coastal zone management
  - 7) Forestry surveys
  - 8) The selection of areas for settlement under the internal  
migration plan
  - 9) Monitoring water, air, land and ocean pollution
  - 10) Monitoring and assessing natural disasters (forest fires,  
earthquakes, volcanic eruptions, floods)

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INDONESIA (Concl.)

- No information on trained human resources is available
- Two universities offer courses on digital image analysis.

Cloud cover: Despite its many advantages, the present LANDSAT system cannot be put to optimum use in Indonesia due to the country's heavy cloud cover.

Statistically (1972-1981), the situation is as follows:

- 0 - 10% cloud cover affects 3.18% of the data
- 0 - 30% cloud cover affects 10.78% of the data
- 0 - 60% cloud cover affects 21.06% of the data.

There are sites in the equatorial zone for which there are no really useful LANDSAT images.

Cloud cover also hinders aerial photography.

Airborne synthetic aperture and imaging radar will be used to obtain ortho-radar images and ortho-photographs, with the contours being derived from digital elevation models.

Indonesia is interested in remote sensors with cloud penetration capabilities.

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Country: MEXICO: 1 958 201 km<sup>2</sup>  
73 011 000 inhabitants (1982 estimate)  
Data obtained from a report by Dr. Jorge Lira of UNAM/IGF

Remote sensing data: LANDSAT  
Aerial photography  
Radar  
NOAA

Origin of remote sensing data: United States  
Local  
Local  
United States

Institutions:

There is no single national programme; instead, there are various groups with regular staff and their own equipment:

UNAM (Universidad Autónoma de México)

- IGF-1975 (Geophysical Institute)
- LIFC-1973 (Interdisciplinary Laboratory of the School of Sciences)

CPNA-1976 (National Water Planning Agency of the Department of Agriculture and Water Resources)

DGG-1978 (Geographical Bureau of the Budgetary and Planning Department)

INIREB-1979 (National Institute for Research on Living Resources)

CCIBM-1975 (Scientific Centre, IBM)

Taken as a whole, the equipment possessed by these groups is valued at approximately US\$ 1 850 000.

The regular staff of these groups:

- 4 persons holding PhD's
- 7 persons holding Master of Science degrees
- 17 persons holding Bachelor of Science degrees
- 15 technicians

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MEXICO (Concl.)

Applications:

Basic and applied research on remote sensing. Physical and mathematic shaping of the environment. Academic training of human resources.

Land use and crop identification with hydrological and geological applications.

The production of mapping information: thematic maps, orthographic projections, statistical tabulations.

Monitoring of tropical vegetation. Climatological studies.

General support for remote sensing projects.

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Country: MOROCCO: 445 000 km<sup>2</sup>  
21 667 000 inhabitants (1982 estimate)

Remote sensing data: LANDSAT  
Aerial photography  
NOAA  
METEOSAT  
GOES

Origin of data: France  
Local  
Casablanca APT (automatic picture transmission) Station  
Casablanca APT Station  
Casablanca APT Station

Institutions: . National Co-ordinating Centre for Scientific and Technical  
Research (1976), presided over by the Prime Minister  
. National Remote Sensing Laboratory  
  
- Plan for training 50 middle- and high-level specialists

Applications: . Ministry of Energy and Mines: Test project for satellite data  
processing, conducted by its Division of Geology: A map based  
on monochromatic photomosaics at a scale of 1:1 000 000 and  
1:2 000 000. The analysis and interpretation of lineaments  
in the Rifa region at a scale of 1:200 000.

Next stage: Regional tectonic studies. The study of relationships  
between regional deposits and circular structures.

. Ministry of Agriculture and Agrarian Reform: Uses remote  
sensing for:

- Updating topographic maps
- Studying field crops, fruit orchards, plant health conditions,  
crop trends, soil humidity
- Studies on erosion, desertification of the southern region
- The preparation of thematic maps: An inventory of water  
resources, flooded areas, irrigation, snowfall, etc.  
(The Ministry of Agriculture has established satellite data  
control points.)

. Meteorology: An APT station has been operating since 1964 at  
the National Meteorological Centre at Casablanca. Meteorological  
predictions are based on infra-red and visible data from NOAA,  
METEOSAT and GOES satellites.

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MOROCCO (Concl.)

- . Mohamed V. University, School of Sciences. Department of Remote Sensing (undergraduate courses in remote sensing).

Project: Mineral deposits in the upper Atlas mountains.

- . Other projects:

- Regional development and soil management: Maps based on remote sensing data on land use and infrastructure will make it possible to prepare a map on population distribution for purposes of projecting rural migration to urban zones and irrigated perimeters. Aerial photos and satellite data will be used with multi-level techniques.

- Geodetic satellites: Earth stations and laser reflectors on the moon to measure displacements between Europe and Africa in the area of Gibraltar.

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Country: NEPAL: 144 000 km<sup>2</sup>  
15 020 451 inhabitants (1981)  
Summary data obtained from a paper prepared by  
Mr. K.D. Bhattarai, Department of Mines, Government of Nepal

Remote sensing data: Aerial photographs  
Landsat MSS  
Aerial photography commenced in 1885, but was first applied  
in remote sensing in 1964  
Use of the LANDSAT MSS began in 1968

Origin of data: Local  
(United States, India)

Institutions: - Ministry of Mines  
- Remote Sensing Centre, founded in 1981

Possesses: Apple II  
Zoom Transferscope  
Double stereoscope  
Color Additive Viewer  
Scanning Stereoscope  
Photo laboratory

Applications/activities:

- Aerial photography was first applied to remote sensing in 1964. The Ministry of Mines and Geology used it in forestry studies involving the preparation of a photogeological map in 1974-1975.
- The First Workshop on Remote Sensing was held in 1976 with the assistance of United States AID and UNDP.
- The Second Workshop on Remote Sensing was held in 1978; a decision was taken at that meeting to establish a National Remote Sensing Centre, which came into being in 1981.
- Remote sensing is particularly useful in Nepal because of its mountainous geography, which makes any other form of obtaining data on the country's natural resources slow and costly. It is especially useful for mapping, monitoring changes in land use, surveys of crops, forests, water resources, geology, etc.

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NEPAL (Concl.)

Some applications:

- . Map of Nepal's geological contours;
- . Map of Nepal's fault density;
- . Possible sites of mineral deposits;
- . Contours and their relationship to Nepal's river systems;
- . Contour line analysis.

Problems hindering the application of remote sensing;

- . Economic constraints on purchasing equipment, training professionals and conducting research.
- . Remote sensing technology is changing very rapidly, hence there is an even greater need for the economic resources required for progress.
- . Building technical know-how.

Basic training: 6-8 months for all professionals working in fields where remote sensing can be applied.

Content: principles, methods, interpretation of remote sensing data.

Advanced training: For those who have already acquired a basic level of training and have 5 to 7 years of experience in the use of remote sensing.

Content: in-depth interpretation, computer-aided analysis.

Executive training: A minimum of one week devoted to the subject of remote sensing in general, its uses, advantages, an overview of methods employed.



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Country: NIGERIA: 923 768 km<sup>2</sup>  
82 392 000 inhabitants (1982 estimate)  
Data obtained from a report prepared by Dr. S.O. Ihemadu,  
of Nigeria

Remote sensing data: LANDSAT  
Radar imagery

Origin of data: United States

Institutions: Department of Forestry, Remote Sensor Unit

Applications:

- Nigerian Radar Project (NIRAD)

LANDSAT images of Nigerian territory have been affected by cloud cover, which made it impossible to conduct a survey of the country's forestry resources.

A solution to this problem has been developed by the NIRAD programme. Radar images are used for mapping at a scale of 1:250 000 in order to prepare corrected mosaics of selected areas at the same scale and at 1:100 000.

With the help of the Federal Department of Forestry and the FAO project on high-altitude forest development, facilities were set up for training and the interpretation of aerial photography, satellite pictures and radar images.

The results of the NIRAD Project have proven to be very useful for various research institutions in the country.

- The Remote Sensor Unit of the Forestry Department has met the needs of various user agencies in fields such as forestry (timber surveys), agriculture, geology (primarily geological maps), cartography (for small-scale modifications) and environmental monitoring (especially desertification).

- Training and research

Remote sensing activities are conducted by universities and specialized institutions. There are over 100 trained specialists.

As part of its project to develop tall tree forests, FAO participates in Nigeria's remote sensing activities in a number of specialized fields.

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NIGERIA (Concl.)

The Regional Centre for Training in Aerial Mapping provides instruction in such survey work and in satellite remote sensing in combination with photo-interpretation.

The International Institute on Tropical Agriculture is working with FAO on agricultural research activities.

- Projects

The Lake Chad project is primarily directed towards the use of sequential satellite images taken during the 1972-1978 drought in order to identify permanent water bodies.

The Kainji dam project includes an analysis of water beds at different times of year to determine the effect on electricity supply.

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Country: PAKISTAN: 803 940 km<sup>2</sup>

87 125 000 inhabitants (1982)

A summary of the paper presented by Dr. Salim Mehmud,  
President of the Space and Upper Atmosphere Research  
Committee (SUPARCO)

Remote sensing data: Landsat (2 000 shots, including 180 CCT's)

Origin of data: NASA, NOAA, NRSA

A portable NASA Landsat station was operating near Islamabad  
from 1976 to 1977.

SUPARCO has decided to set up an earth station capable of  
gaining direct access to Landsat and SPOT.

There are plans to develop airborne remote sensing capabilities  
in order to supplement satellite data.

Institutions:

- The Centre for Remote Sensing Applications (RESACENT), which is part  
of the Space and Upper Atmosphere Research Committee (SUPARCO) of  
Pakistan, has been in operation since 1974.

The equipment it possesses includes: IBM 4331

Density Slicer

Colour Additive Viewer

Zoom Transferscope

Multispectral Camera

Diazo Printer

Densitometer

(An Image Analysis System is  
on order.)

Applications/Training:

Visual and digital interpretation techniques have been used. The results of  
this research have been presented at a number of national and international  
seminars and conferences.

Some of these techniques are:

- Mapping flooded areas;
- Identifying areas of flooding and salinization;
- Mapping the courses of rivers, particularly variations before and  
after flooding;
- Studying the morphology of the Indus Delta;
- Estimating snow run-off and the subsequent volume of flow in rivers;
- Identifying crops and their areas;

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PAKISTAN (concl.)

- Conducting forestation studies;
- Identifying and estimating mangrove vegetation in the Indus Delta;
- Estimating sedimentation in the Tarbela and Mangla dams;
- Preparing soil-use and geological maps;
- SUPARCO has been making an effort to promote the use of remote sensing and to educate the potential users of such data; to this end, it has offered nine training programmes over the past six years on the theoretical and practical aspects of these techniques. A total of 150 scientists and engineers have benefited from these programmes.
- Pakistan has offered to make RESACENT available to the United Nations Commission on the Peaceful Uses of Outer Space as a regional training centre.
  
- Seminars: The first meeting, sponsored by Pakistan and the United Nations, was the Regional Training Seminar. It was held in 1977 and was attended by representatives of 18 countries in the regions served by ESCAP and ECWA.

The second seminar, sponsored by Pakistan and FAO (March 1984), was the National Training Workshop on Computer-Aided Remote Sensing Techniques for Land Use Management and Agricultural Crop Assessment.

Future activities:

- SUPARCO is interested in setting up an earth station having direct access to Landsat and SPOT.

There is interest in imaging radar techniques and in the thematic mapper.

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Country: PHILIPPINES: 300 000 km<sup>2</sup>  
50 740 000 inhabitants (1982 estimate)  
Data source: Report by Mr. Ricardo Umali, Natural  
Resource Management Centre, Quezon City, the Philippines.

Remote Sensing Data: LANDSAT

Origin of Remote Sensing Data: United States, Australia

Institutions: Founded in 1976, the Natural Resource Management Centre (NRMC) is the organization within the Philippine Government which implements remote sensing programmes. It specializes in the digital processing of CCT's (computer-compatible tapes) using an interactive system for digital image analysis, supplemented by the visual interpretation of satellite images.

Applications/Training:

Since 1977, the NRMC has studied and analysed over 200 shots from LANDSAT 1, 2, 3 and 4 for use in natural resource surveys, the monitoring of critical resource systems and the assessment of environmental deterioration. To date, it has produced over 342 thematic maps based on LANDSAT images, aerial photos, field data and supplementary information on forest cover, as well as ecological, contour, structural land-use and other maps.

- 1) Forestry resources: In 1977 a complete survey of the Philippine's forests was carried out. The information was updated in 1979 and 1980. In 1982, the NRMC, the Office for Forestry Development and the University of the Philippines undertook a project aimed at updating these statistics. They are using aerial photos, LANDSAT imagery and infra-red photographs to produce a map at a scale of 1:250 000. Another ongoing monitoring activity relates to deforestation and to the assessment of the performance of companies holding logging contracts. Recent aerial photos and LANDSAT imagery are used.

A recent multi-level monitoring study which employs Landsat images and aerial photo samples has provided estimates that fall within an acceptable range of accuracy as well as classificatory data which is nearly as detailed as the information obtained from aerial photography.

- 2) Geology: A contour line study in the mining district of Baguio demonstrated that contour lines in areas known to contain gold and copper ore deposits can be used to pinpoint sites for exploration.

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PHILIPPINES (Cont.)

- . Areas that are prone to earthquake damage were identified in maps that indicate the risks of seismic activity. The latter were based on an analysis of contour maps, as well as lithological and tremor-frequency maps. At a scale of 1:500 000, this map is useful in soil-use planning.
- . In 1979, the data on the fault zones in the Philippines were updated using photo-interpretations of 100 enhanced LANDSAT images and band quotients at a scale of 1:100 000 to detect heretofore unknown major and minor contour forming part of the Luzón fault system.
- . In 1981, the applicability of LANDSAT imagery to the mapping of farms along the Bued river basin was studied. The results were highly successful.

3) Coastal and lake marine resources:

- . LANDSAT data are used in assessing the country's coral resources, which are threatened by over-exploitation. The Apo coral reef, an atoll to the east of Muidor Island, was mapped in 1978. Despite the shallowness of the LANDSAT bands, the results indicated that automatic digital mapping of the major physiographic structures and the variations of the coral floor was possible. Similar studies are being conducted in other areas of interest to the Ministry of Natural Resources.
- . A survey of coastal resources and the environment using MSS (multi-spectral scanner) data. This is a three-year programme, conducted in co-operation with the National Scientific and Technological Authority (NSTA), aimed at carrying out a resource survey and a multi-disciplinary analysis of the environment in selected areas of north-eastern Luzón. Satellite images and field data are processed by computer.
- . In 1978, a multi-spectral digital analysis of LANDSAT images was conducted to detect and monitor the proliferation of water hyacinth (*Eichhornia Crassipes*) in Bay lake. Distribution patterns, estimates of density, the area covered, etc., were obtained from digital and visual analyses using the Image 100 System.
- . Satellite data are being used as part of a five-year plan to analyse environmental changes along the coastal zones of selected areas in order to determine the relationship between such changes and the sea and fishery product quality.

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PHILIPPINES (Cont.)

The information will be used in modifying environmental conservation laws.

- . LANDSAT and auxiliary data will be used to detect and map large bodies of water with a view to identifying potential sites for lake fisheries.
- 4) Land use: One of the Centre's first projects was the preparation of land-use maps for the National Development Authority based on LANDSAT data at a scale of 1:50 000. This project covered some 26 municipalities in the southern Tagalog region. The project concerning the mapping of the natural resources of Palawan Island was also completed. This project, which was launched at the request of the National Counsel on Integral Development (NACIAD), involved data on land use, water resources and the road network at a scale of 1:250 000.
  - . The classification of metropolitan Manila according to land use and patterns of change was done using digital analysis. Thematic maps at a scale of 1:100 000 show its geographic location, residential and commercial zones, rice paddies, grasslands, open spaces, brushlands, fish hatcheries and forests for the years 1972 and 1976.
  - . Mapping land use is an ongoing project of the Centre designed to update regional maps at a scale of 1:250 000 using LANDSAT data.
  - . In recognition of the Centre's capacity for the production of plant-cover maps, the Forestry Development Office has requested the Centre to prepare regional maps at a scale of 1:500 000 indicating the location of all open, denuded, and forested land in the country. The project is to be completed this year. The maps will provide input for the National Committee on Land Use in its assessment of the country's soil resources.
  - . One of the Centre's continuing projects is the preparation of a national resource and statistical profile to update the available information on land, fisheries, mineral and forestry resources. This is one of the Centre's valuable contributions to the decision-making process in relation to resource management.

The Natural Resource Management Centre has sponsored the following conferences and workshops:

- 1) 1978: Twelfth International Symposium on Environmental Remote Sensing, in co-operation with the Earth Resources Institute of Michigan (ERIM).

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PHILIPPINES (Concl.)

- 2) 1983: Second Agricultural Symposium of Asia on the Application of Remote Sensing to Agriculture and Resource Development, in co-operation with the University of Tokai, Japan.
- 3) 1983: Workshop on the Implementation of Remote Sensing Technology for Economic Development, in co-operation with the East-West Environment and Policy Institute of Hawaii.
- 4) 1984: Regional Conference on Multi-Level Remote Sensing in Forestry Applications, in co-operation with ESCAP.

Training:

The Philippine Government is promoting training in satellite remote sensing and interpretation of LANDSAT data through the Natural Resource Management Centre.

- Regional training in digital imagery interpretation in forestry applications (15-26 October 1984).

Future needs:

- . The trend in the use of satellite data is such that there will be a need for the more specific and detailed data that the new sensors, which have better spatial and spectral resolution (SPOT and TM), can provide. Radar systems' capability to penetrate cloud cover will be useful for zones with heavy cloud cover.
- . TM and SPOT
  - Identification and maps of forests according to type and species
  - The monitoring of logging activities
  - The detection of pests and forest fires
  - Repetitive coverage as a means of monitoring reforestation, forest growth and logging
  - The evaluation of water resources
  - Monitoring coastal resources, the evaluation of nutrients, the ecological conditions of coral resources, the mapping of mangrove swamps and the identification of the species in them
  - Detailed land use classification and at a large scale for urban and rural planning purposes requires the better resolution and the larger number of classes that can be identified from increased spectral resolution.



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Country: REPUBLIC OF KOREA: 39 331 000 inhabitants (1982 estimate)

Remote sensing data: Satellite: LANDSAT  
Aerial photography

Origin of remote sensing data: LANDSAT: Foreign and United States stations

Institutions: The Ministry of Science and Technology runs the remote sensing programmes

Applications:

Past events:

- 1972. Research on the geological and structural features of the Korean peninsula, in co-operation with EROS/NASA. The results proved the usefulness of LANDSAT data in studying lineaments and seasonal variations in humidity.
- 1974. The Ministry of Science and Technology (MOST) undertook an experimental programme on remote sensing in which governmental institutions participated. The purpose of the programme was to study the applications of satellite data in various areas. It yielded positive results in monitoring estuary waters, forestry surveys, soil use, geology and mining exploration, but the results in relation to meteorological studies were negative.
- 1976. Under another MOST experimental programme, remote sensing was applied to coastal mapping, off-shore surface circulation, forestry surveys and geological analysis.

The results obtained using LANDSAT were successful in small-scale work, but the resolution was too coarse for land use and environmental studies.

The delay involved in obtaining satellite data rendered them useless for dynamic studies.

Following this programme, preference was given to aerial photography for most applications, except in the field of geology.

- Remote sensing was used in analysing geological faults and in improving geological maps.

Satellite remote sensing has gradually come into use in studies on forestry, environmental pollution, oceanography, land use and hydrology.

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REPUBLIC OF KOREA (Cont.)

A number of experimental studies on pollution which were conducted in Seoul in 1979 have yielded excellent results.

- The Republic of Korea takes an active part in the regional programmes of ESCAP and takes advantage of the opportunities provided by seminars for the exchange of experiences and the training of professionals.
- Korea and Japan conducted a co-operative project on the study of geological formations using LANDSAT imagery during 1980 and 1982.

Current applications (1984)

- Remote sensing data processors have been installed in KIER and KAIST which meet the needs of all current users in Korea, whose number is growing. Remote sensing applications have also been extended to include Korean universities and institutes.

Futures programmes

Remote sensing applications in the following areas will be encouraged:

- Geological mapping and mining exploration, geothermal exploration, groundwater, tectonic analysis. It is hoped that Thematic Mapper and radar data may be used.
- The industrialization of the country will entail problems connected with increased demand, urban expansion and environmental pollution. These problems will have to be resolved in order to protect the earth and its peoples.
- Satellite data with a spatial resolution of over 30 m, better spectral resolution and other features, such as those of synthetic-aperture radar will be needed.
- Inasmuch as more up-to-date data must be obtained in order to study the dynamic phenomena of the earth's surface, an earth-based satellite data receiving station is needed. The developing countries consider the cost of such a station to be too high; nonetheless, the use of aerial photography to monitor reforestation is also very costly.
- The problem of environmental pollution cannot be tackled using manual methods because they are too costly and too slow. Remote sensing techniques are a valuable method of detecting surface temperatures and smog.

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REPUBLIC OF KOREA (Concl.)

- There is a great deal of interest among oceanographers as regards the use of satellite data for monitoring ocean currents, studying water pollution in estuaries, etc.
  
- There is also a need for satellite data in connection with water resources and their management, flood control, irrigation, hydroelectricity, and the selection of dam sites.

