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In this paper basic information about the Brazilian LANDSAT Tracking, Receiving Processing and Distribution System operated by INPE is presented. It includes the Cuiabá Tracking and Receiving Station and the Cachoeira Paulista Electronic and Photographic Processing Labcratory and Distribution Center. The localization of the receiving facilities at Cuiabá allows the coverage, with a periodicity of 18 days, of the entire Brazilian territory, as well as, most of South America. The increase of the users community - today with more than 1,200 participant organizations - and the increase of the volume of images produced - near 20,000 in 1979- are effective demonstration of the importance that remote sensing has today in Brazil. Types and prices of products available, product request and related items are discussed. Also, the already planned future achievements of the Brazilian Remote Sensing Satellite Program are briefly describe.

17.Remarks

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1. INTRODUCTION

The Brazilian territory with near eight and a half million square kilometers is not vey well known, mainly with respect to its natural resouces.

Consequently, remote sensing, especially by satellites, which allows the survey of large areas very rapidly and at relatively low cost, is an important tool for a large and developing country like Brazil to increase the knowledge about is renewable and non-renewable resources and to monitor the modifications that take place on its environment.

The Brazilian remote sensing activities started in 1968 when a group of researchers from several government institutions, under the coordination of the Institute for Space Research - INPE, participated in a remote sensing course offered by NASA in the United States. During the following two years, INPE's main concern was to train persons from other institutions which were potential users of the new technology, as well as to establish its own research group. Also an important step in the program was the acquisition by INPE of a 10-passenger size twin-engine Bandeirante aircraft equipped with several sensors, like a wild RC-10 Camera,an I^2S Multispectral Camera and a Bendix Scanner.

In 1970, two different studies were originated from INPE. The first one was related to the installation of a LANDSAT receiving and processing station in Brazil and the second to the survey of part of the Amazon region (about 44,000 square kilometers) using a side-looking radar. These studies gave birth to the two major existing remote sensing programs in Brazil: the Satellite (LANDSAT) Remote Sensing Program whose leading organization is INPE and the Radar

(RADAMBRASIL) Program, whose leading organization is the National Department of Mineral Production (DNPM).

The scope of the radar project was modified several times after 1970 and in 1975 it was expanded to cover the whole Brazilian territory becoming the RADAMBRASIL Program, that had as objective to survey the natural resources of the whole national territory in a level of detail compatible with a 1:1,000,000 scale focusing on geology, geomorphology, soil, agriculture, aptitude, ecology and potential land use.

The Satellite Remote Sensing Program, on its side, has as objective the reception, processing and dissemination of satellite remote sensing data (today basically LANDSAT data) and the development of new methodologies for the application of these data in the survey and monitoring of natural resources and land use, and the observation of the environment. The main available facilities are a LANDSAT receiving and processing station, all operational meteorological satellites (GOES and TIROS-N) receiving and processing stations, two automatic image analysis systems (G.E. Image-100 and Bendix MDAS) and the two-engine Bandeirante aircraft.

Chapter II presents the most important characteristics of the existing Brazilian LANDSAT Tracking, Receiving, Processing and Distribution Systems and in Chapter III the already planned future achievements of the Brazilian Satellite Remote Sensing Program are briefly discussed.

2. LANDSAT TRACKING, RECEIVING, PROCESSING AND DISTRIBUTION SYSTEM

2.1 - TRACKING AND RECEIVING SUB-SYSTEM

INPE's Tracking and Receiving Station was established by May 1973 in the city of Cuiabá, Capital of the State of Mato Grosso. This localization allows, with a periodicity of 18 days, the coverage of the entire Brazilian territory and most of South America, as shown in Figure 1. The coverage corresponds to a nominal antenna deviation angle of 4.5^{o}. However, reception at lower angle is usually possible.

A 9-meter parabolic antenna is used to receive the remotely sensed data gathered and relayed to earth by the LANDSAT series of satellites. It can automatically look out the spacecrafts and track them while they are within the acquisition range of the station.

The facility can presently receive data from the Multispectral Scanner (MSS) and from the Return Beam Vidicon (RBV), as well as telemetry data.

During the acquisition, the MSS or RBV stream can be checked in real time for assessing the cloud cover percentage and system performance. A Cathode Ray Tube (CRT) monitor is used to produce black and white 70mm quick-look imagery, which are framed and annotated, besides corrected for earth rotation.

The data are recorded on magnetic tapes which are sent by air freight to São Paulo and afterwards to Cachoeira Paulista processing site, as shown Figure 2.

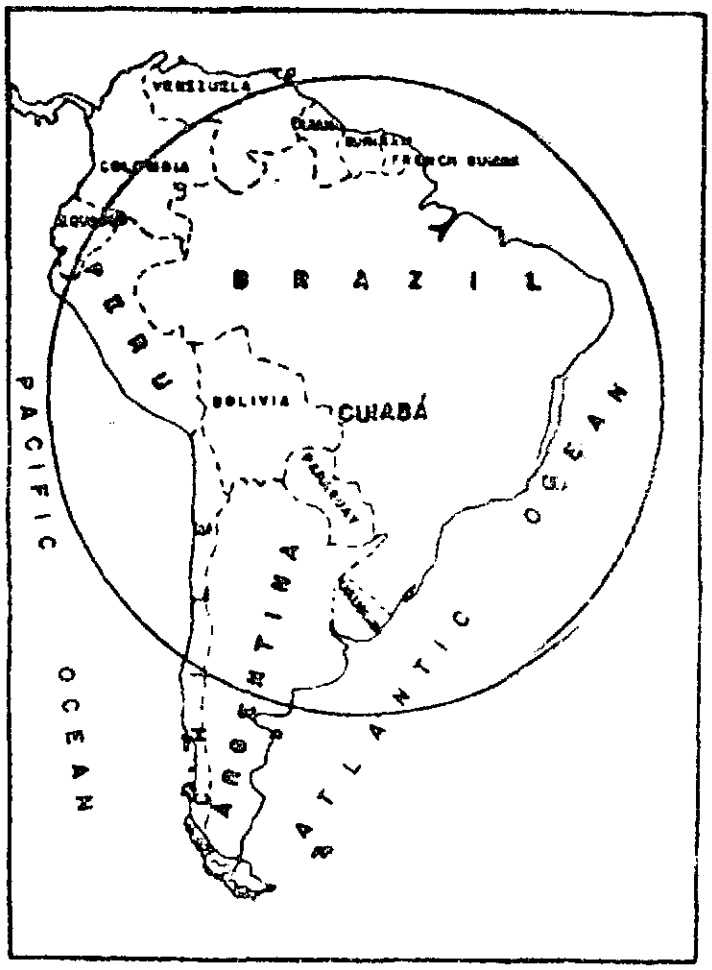

Figure 1 - Cuiabá Ground Station Coverage

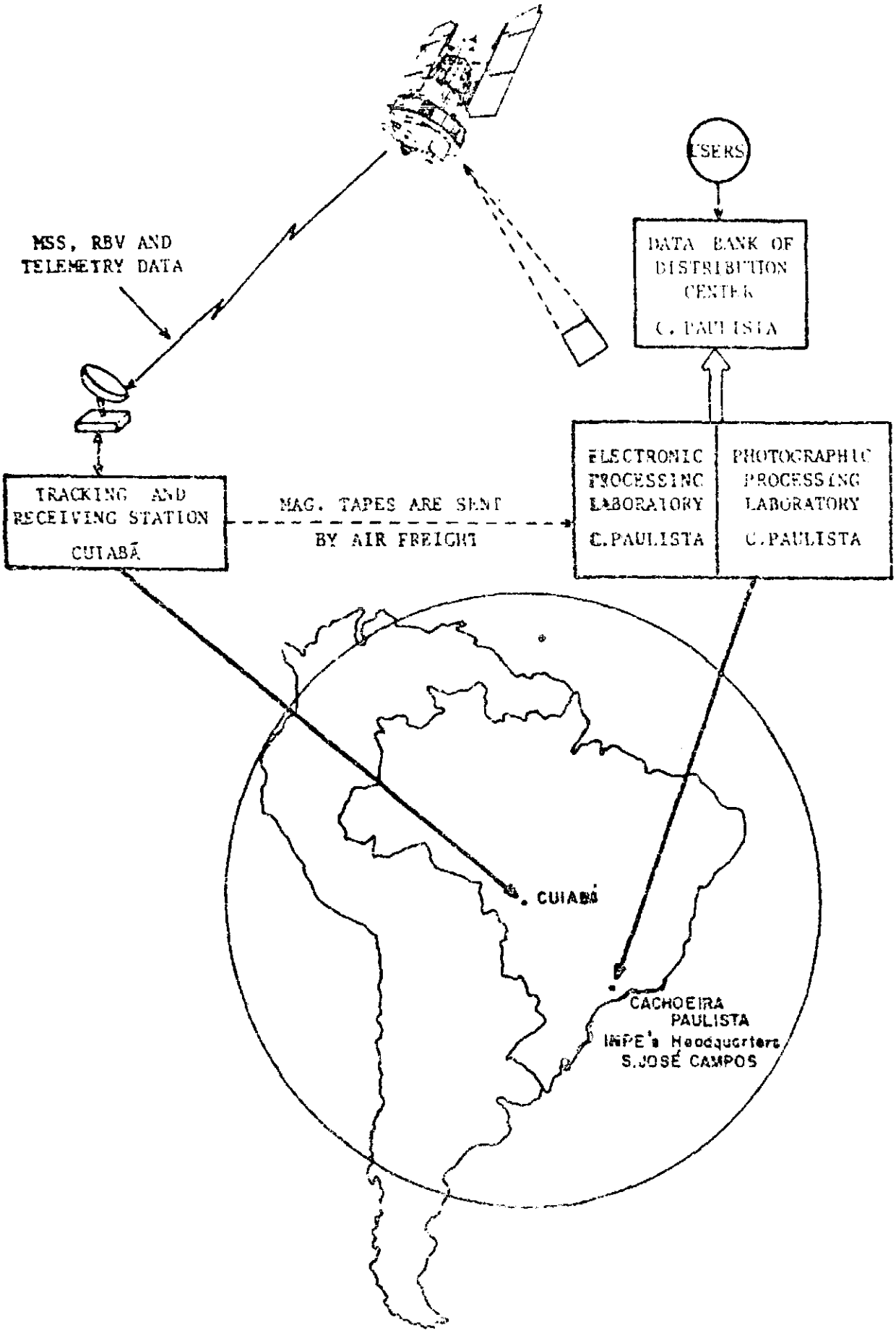

Figure 2 - The Brazilian LANDSAT System.

Meteorological satellite data are directly received at INPE's São José dos Campos station, where they are processed.

There are today near 33,000 LANDSAT-1 (MSS) recorded scenes, over 30,000 LANDSAT-2 (MSS) scenes and over 20,000 LANDSAT-3 (MSS) scenes. Concerning RBV data, the station already recorded near 300 scenes from LANDSAT-2 and over 12,000 scenes from LANDSAT-3. These numbers give approximately a total of 85,000 MSS scenes and 13,000 RBV scenes stored in INPE's Data Bank.

2.2 - PROCESSING SUB-SYSTEM

The Electronic and Photographic Processing Sub-system is located in the city of Cachoeira Paulista, State of São Paulo, 110 kilometers away from INPE Headquarters in São José dos Campos. It started its regular operation by the end of 1974. Cachoeira Paulista is located halfway between the cities of São Paulo and Rio de Janeiro.

The Electronic Processing Laboratory has as main functions:

- processing the video-tapes recorded at Cuiabá Tracking and Receiving Station for the generation of high resolution 70mm B & W films, which contain the several channels of sub-scenes of a given sensor (MSS or RBV);
- processing under user's request, the MSS data for the production of computer compatible tapes (CCT) in 9 tracks, 800 bpi;
- visualization in a colour moving window display of any required pass of the satellites, as recorded in video-tape or CCT, for quality control and research purposes;

- processing of precision images, under selected scene basis, for cartographic applications;

- processing of distorted LANDSAT scenes for the combined use whith radar or SKYLAB imagery.

It has as basic equipments:

- two small computers (DEC PDP 11/15) with 56 Kbytes of memory each (called data processor and process controller), including two magnetic tape units, one removible disk (1,2 Mbytes), one paper tape reader, one line printer, two video terminals and one card reader;

- one tape recorder, 28 tracks, for play-back the MSS data tape;

- one tape recorder for RBV data;

- one tape recorder for telemetry data;

- one Electron Beam Recorder and Controller for film production;

- one moving window display for visualization;

- one data grid for digitalization and geometric corrections;

- several formatters, interfaces and controllers.

Photographic products are geometric and radiometrically corrected, including sensor mismatch and sun elevation compensation. CCT's are only radiometrically corrected.

This production oriented sub-system has the capacity of producing near 100 scenes per day in film (3 shifts of 8 hours each).

The photographic Processing Laboratory has as main functions:

- automatic processing of the first generation B & W films, produced in the electron beam recorder;
- automatic processing of a 70 mm second generation film as work copy;
- duplicating and enlarging the work copy scenes for the production of user products;
- automatic generation of false colour imagery using selected channels of the MSS sensor and transformation of the colour master film into an user product;
- manual processing of airborne and satellite images for mosaics.

First of all, the Photographic Processing Laboratory must worry about processing with fidelity the first generation film. For control purposes, test strips of the same film are passed through the machine, at least just before and after each roll processing, in order to establish its working conditions. Feedback information to the Electronic Processing Laboratory is provided related to processing problems, such as density range, focus, spots, scratches and misalignments. After that, a work copy is produced. The more stable the first generation film processing is, the easier the obtention of the work copy will be. The processing of this second generation is flexible enough for correcting any film variation which may occur due to hardware or material limitations.

In the same way that the control of the first and second generation exists, it also exists a control for the processing of products that are delivered to users. A well trained quality control group inspects all user products before shipment.

2.3 - DISTRIBUTION SUB-SYSTEM

INPE offers to its LANDSAT users several photographic and digital products, intending to fit most of many particular applications. Film products, both B & W and color (for MSS) are presented in sizes 70 mm and 9 1/2". Paper products range in scales from 1:1,000,000 to 1:500,000 for color and from 1:1,000,000 to 1:250,000 (MSS) or 1:100,000 (RBV) for B & W.

To support the users in their quests for data in their work with LANDSAT products, INPE provides several kinds of services and tools.

A main tool available to any user is the LANDSAT Catalog, which is published annually, with quartely updates, containing the images made available during the last period. The entries are ordered by path, date and row to facilitate access. Information listed in the Catalog are (besides path, row and date) center latitude and longitude, cloud cover, quality and visibility (this one relating mainly to the amount of haze) assessments, Sun elevation angle, geometric correction level, satellite number, revolution number and the image identification code, for each image. The catalog is subscribed to with a nominal fee, intitling the user to receive all the issues in that year and eventual corrections made in the future to entries appearing there.

When a period is closed, the images pertaining to that volume of the Catalog are microfilmed and, althoug not made available for purchase, copies of the microfilms are sent to the five User Service Centers that presently INPE maintains throughout Brazil (Figure 3 shows the localization of the existed centers, as well as the other two that, in a near future, will be installed) to enable users to view the images and personally evaluate their quality and cloud cover before ordering them. For MSS, band 5 is the one microfilmed, provided it is available.

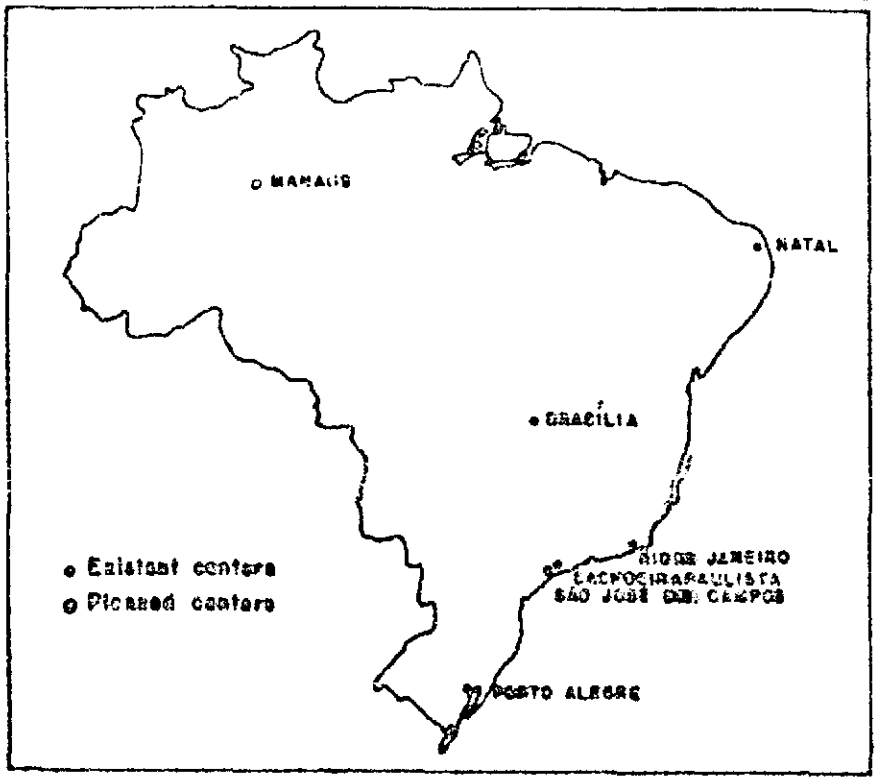

Figure 3 - User Services Centers.

Recently, INPE started selling quick-look images, which are lower-resolution, uncorrected versions of the final products. These products can also be used, as they cost about half the price of the corresponding final product, to select images to be ordered in more expensive presentations. Quick-look is available only for MSS, in 1:1,000.000 B & W paper, normally from band 5.

INPE's prices are of the same level than those charged by EROS Data Center for corresponding products, as determined by the Memorandum of Understanding signed between NASA and COBAE (Brazilian Commission for Space Activities). This low-price policy is mainly intended to incentivate the user of LANDSAT data among the technical community of Brazil and South America.

However, the total selling revenue obtained is not sufficient even to cover INPE's expenditure on consumables. For example, last year budget of INPE's Department of Image Production- which is responsible for the LANDSAT system - was near 1.2 million dollars, including NASA's fee of 0.2 million dollars, and the total revenue obtained was approximately 0.25 million dollars. Devaluation of equipment and technical and administrative overheads were not included in the above mentioned budget of 1.2 million dollars.

A difference concerning payments from other LANDSAT user centers, is that INPE charges for products *after* the users receive them. This was made so due to the fact that Brazilian government agencies, which represent a major percentage of the users, have regulations restricting paying for goods in advance.

To help control the debts and payments of the user community, a small accounting system has been developed on the Support Computer System, consisting of a DEC PDP - 11/34 with 96 K bytes of memory, 7.5 M bytes of disk (2.5 Mbytes on a removable cartridge),

one line printer and two 800 bpi/75 ips magtape units that are shared with the production computer system (the two PDP 11/15). This accounting system keeps track of each user's balance from punched cards with shipping lists data and from terminal-entered payments information.

Concerning delivery times, a good figure for the average in fulfilling an order is one month. Some requests take less and some take longer, depending on the volume of data. However, an effort is presently made in order to reduce as much as possible the average presented above.

Back to user services, free of charge computer search printouts can also be provided under user's request. However, due to limitations in computer power and storage space in the system that handles the data base (the PDP 11/34), the index resides on tape and searches are, consequently, not very flexible. Currently, the only geographic access keys are the path-row codes. Options that can be specified are minimum quality, maximum cloud cover, minimum Sun elevation angle and the period of interest. The search program lists up to 12 images within the period, satisfying the selected restrictions. If there are more than 12 suitable images in the index, only the most recent 12 within the period are shown. The informations printed for each image are basically the same ones presented in the Catalog, except for latitude and longitude.

In spite of the mentioned constraints, more flexible retrievals of INPE's index can be made through EROS Data Center, which is kept updated with respect to the additions made to INPE's data base. INPE's images are an integrant part of ERO's index and thus can more easily be made available to the rest of the world.

Concerning support for the work with LANDSAT products, INPE has as already mentioned two automatic image classification systems which can be used with LANDSAT MSS CCT's for cathegorization of areas, using training sets selected by a human operator. One of them is a Bendix M-DAS, which is more oriented towards smaller training sets and lower-volume production. The other is a General Electric Image-100, which has higher throughput and has several additional flexibilities over the M-DAS. The I-100 is located at the main INPE facility, at São José dos Campos, SP, and operated by the Remote Sensing Department of INPE. The M-DAS belongs to the Image Production Department and is installed along with the Electronic and Photographic Processing Laboratories, in Cachoeira Paulista, SP. An experienced team of remote sensing researchers can give the users all the assistance needed in working whith these systems, and can also perform the interpretation of photographic products for the users, if requested.

Since starting its activities with LANDSAT, INPE has achieved good results in disseminating this powerful tool through the user community. Product demand and number of users have grown steadily since 1973. In 1979 Brazil delivered more than 19,000 images to users, which brought us to a position second in the world in terms of LANDSAT production (see Table I below). It is expected for 1980 a volume of 22,000 images.

TABLE I

NUMBER OF IMAGES DISTRIBUTED PER YEAR

YEAR	1973	1974	1975	1976	1977	1978	1979	1980(*)
IMAGES	323	1,230	2,094	7,564	10,045	18,049	19,051	3,500
CCT	-	10	55	141	132	141	146	18

* *March, 1980*

From 3 users in 1973 (see Table II below), INPE's LANDSAT System presented more than 1,000 (mostly institutions) at the end of 1979, 226 of them were foreign.

TABLE II

NUMBER OF USERS

YEAR	1973	1974	1975	1976	1977	1978	1979	1980(*)
TOTAL NUMBER OF USERS	3	27	69	156	301	646	1161	1273

* *March, 1980*

Presently, INPE is committed to technically improve its products MSS and RBV (several tests and experiments are being succesfully conducted with the goal of bringing the geometric accurary of the images down to 50 meters, so they can be used as a reliable source for updating existing maps and producing 1:250,000 maps for a vast portion of the interior of Brazil, which is very poorly mapped) and negotiating a system to acquire and process the MSS and Thematic Mapper from LANDSAT D. The better characteristics of this sensor concerning geometric and radiometric resolution, allied to the spacecraft's better attitude measurement and control make it an invaluable instrument to help Brazil better monitor, evaluate and plan the use of its prolific natural resources.

The distribution sub-system is located in Cachoeira Paulista.

To finalize this Chapter, it is worthwhile to mention that for the operation of the whole LANDSAT system, INPE's Image Production Department has a staff of approximately 80 people, almost 20% of them have at least a B.S. degree.

3. FINAL REMARKS

Besides the LANDSAT Tracking, Receiving, Processing and Distribution System, INPE has a Remote Sensing Department with a research staff of near 100 elements devoted to the development of application methodologies in the areas of agronomy and forestry (crop survey, soils survey, natural forests survey, deforestation and reforestation), geology (regional geological mapping, mineral and oil exploration), oceanography (marine fishing charts, physical oceanography, upwelling), hidrology, cartography, geography (potential and actual land use), environment (pollution in water bodies, sedimentation in water reservoirs, desertification). As a rule, everytime an organization demands to INPE an specific application, the

corresponding methodology is developed with the participation of elements of that organization, making the technology tranfer more effective.

On-the-job training, especialized seminars and graduate courses are also offered.

Today, remote sensing is a reality in Brazil. The near 1,000 Brazilian users community has been very active. For example, in the 1st. Brazilian Remote Sensing Symposium that took place in São José dos Campos in November 1978, more than 100 technical and scientific papers were presented.

Due to this massive utilization of remote sensing satellite data, two further steps were already taken by the Brazilian Government.

The first one, as already mentioned, is the decision to upgrade the present LANDSAT system to receive and process MSS and Thematic Mapper Data from LANDSAT-D as well as SPOT data.

The second is related to the project, construction, integration and operation by INPE of two Brazilian remote sensing satellites, which will be launched by a Brazilian launcher in the 1987-1989 period. They will have a nearpolar circular heliosynchronous orbit of approximately 650 km and total mass of about 150 kg. The remote sensing camera will use CCD detectors and the images will be produced in four channels with near 50 meters resolution.

4. ACKNOWLEDGEMENT

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