ACTIVITIES IN EARTH REMOTE SENSING SURVEYS IN BRASIL

by

FERNANDO DE MENDONÇA

REPORT LAFE-163

September 1971

Prepared for:

FAO Meeting

Rome - Italy

PR - Conselho Nacional de Pesquisas
Instituto de Pesquisas Espaciais (ex-CNAE)
São José dos Campos - SP - Brasil

ACTIVITIES IN EARTH REMOTE SENSING SURVEYS IN BRAZIL

Fernando de Mendonça
Instituto de Pesquisas Espaciais (INPE)
(ex-CNAE)
São José dos Campos, São Paulo
Brazil

Abstract

This report presents a brief description of the Brazilian remote sensing program including the different phases covered so far and the steps to be taken during the next couple of years. The emphasis is put in the organization of the program and the preliminary results rather than on the instrumentation. One of the short range objectives is to have our full system in a position to efficiently use the data to be acquired starting next year by the NASA Earth Resources Technology Satellites (ERTS-A).

Prepared for:
FAO Meeting
Rome-Sept. 1971

1. INTRODUCTION

By 1965, as a result of the close association between NASA's Office of International Affairs and the Brazilian Space Agency (CNAE), a program was started in Brazil to implement research in the field of application of remote sensing to natural resources surveys. In 1966 NASA suggested a cooperative program involving the aerial survey of certain selected areas which were to be used as lunar analogues. This initial idea was later modified into a much broader remote sensing program of natural resources. A year's time was spent by a working group coordinated by CNAE (now INPE) and composed of members of two dozen different agencies of our Government, concerning the policies to be adopted. A visit in mid 1967 to the United States, sponsored by NASA and CNAE, was made by 12 persons of this group.

Early in 1968, a cooperational program was established between NASA and CNAE (now INPE) by means of a Memorandum of Understanding approved by an exchange of notes between the two Governments. This program called for 4 different phases. The initial one (Phase A) took place in 1968 and had to do with the crucial elements of such a project, namely, the training of individuals in order to have qualified human resources. The training was provided by NASA at MSC for a period of six months and included many field trips to various test sites in the U.S. besides the course work.

The fourteen researchers returned to CNAE and trained an additional group of forty people while beginning Phase B. This phase included the selection and development of test sites, the planning of instrumentation for a Brazilian aircraft, the establishment of data processing facilities, a central data bank, etc. Phase B is ending presently. A third part (Phase C) consisted of a NASA aircraft mission in July 1969 over our test sites for agriculture,geology oceanography, hydrology and polution.

The preliminary results of these flights were discussed in a meeting in Rio early 1970 and the final results were discussed in a meeting with international participation which took place in October 1970 at São José dos Campos. In addtition to these NASA flights, two series of flights were performed by the Brazilian group especially for coffee agriculture with color and false color films. One after a heavy cold front period in the state of Paranã and the other for surveying coffee plantations affected with Hemileia vastatrix (Coffee Leaf Rust). Some of these results will be presented later in this report.

Phase D, now starting, will use INPE's aircraft and laboratories, the in-house project group and six additional groups of the participating agencies and organizations.

2. OBJECTIVES

The systems engineering group being formed is being polarized to the following objectives besides the technical aspects of sensors and associate techniques:

2.1 - Agriculture and Forestry

- Resolve and develop identification keys for crops; i.e., coffee, citrus, sugarcane.
- Distinguish between red (good) and yellow (poor) soils.
- Define weed species.
- Designate various growth stages of sugarcane.
- Locate noncitrus orchards.
- Classify natural vegetation (trees and shrubs) as mature or as immature.
- Construct a soil type map from photographic analysis of types of vigor of vegetation cover (bog, half bog, humic gley, low humic gley).
- Classify pasture-land vigor under different levels of grazing, drainage, and infestation.
- Define citrus species, detect diseased areas and stages of disease.

- Distinguish between two major varieties of bananas and detect areas of disease.
- Locate Irish potato crop, detect diseased areas, and discriminate water-stressed areas from water-deficient areas.
- Define coffee species, detect diseased areas and stage of disease.

2.2 - Geology

- Chart soils, rocks, laterite, and color variation of these material within the area.
- Lay out vegetation and outcrop patterns in the area.
- Determine regional structure and compare with existing geological map data.
- Improve recognition signatures for hematite, itabirite, canga and manganese so it can be identified through diurnal radiometric temperature variances.
- Apply the system to geologically unknown areas of the country.

2.3 - Geography

- Discriminate between buildings of various types, age, height and construction.
- Delineate and identify urban and rural/urban fringe landuse types, that is, industrial, residential,etc.
- Study relationship between Inselberg (Bornhardt) geomorphology and landslide processes.
- Obtain empirical data on porosity and permeability zoning in relation to zones of landslide occurrence.

2.4 - Hydrology

- Determine, using dyes, the vectors of watermotion during ebb tide in important bays.
- Determine dispersion tensors of surface water (intensity).
- Test detection and motion of waste film on surface waters of the area.
- Determine whether known sources and types of pollution can be detected; delineate and discriminate as to biological, chemical, etc.
- Characterize sediments deposition and movements at various depths with various film/filter combinations.
- Study points of cool, fresh water inflow into bays.

2.5 - Oceanography

- Define distribution of sea-surface thermal patterns.
- Locate and define possible upwellings in the sea and study its mechanisms.
- Establish Brazilian current boundaries.
- Characterize the near-shore currents.
- Distinguish extent of bottom vegetation.
- Delineate shorelines, subsurface topography and water depths (hydrographic mapping).

3. ORGANIZATION AND MANAGEMENT

Since the coordination of the project for participating agencies was not established by law, and since INPE (ex-CNAE) does not transfer or control funds to external groups, the process of coordination apparently, in the case of Brazil, can only be accomplished by: the quality of the in-house research group for interfacing, the centralization of automatic data processing, data bank, sensor technology groups, studies of evaluation of decision oriented resources and models and future focal point for the ERTS data analysis, use and redistribution.

It is hoped that by means of such a scheme, redundant work will be minimized. For illustrative purposes Figures 1 and 2 show the organizational charts of INPE (ex-CNAE) and of the remote sensing project (SERE) with its interfaces. This project counts with over ten percent of our staff of 540 people and a growing number of investigators from the participating agencies.

Groups of participating agencies in principle spend a week out of every month working jointly with the in-house group of the same disciplines.

4. INSTRUMENTATION

4.1 - The laboratory instrumentation is characterized by the needs of the different functional groups. It includes:

- Optics and electronics.
- Data bank and ground truth for the various disciplines.
- A photo lab with:
  . Automatic black and white processing of up to 9.5 inches wide films.
  . Semi-automatic color film processing up to 9.5 inches wide films.

ORGANIZATION CHART OF THE INSTITUTO DE PESQUISAS ESPACIAIS (ex CNAE)

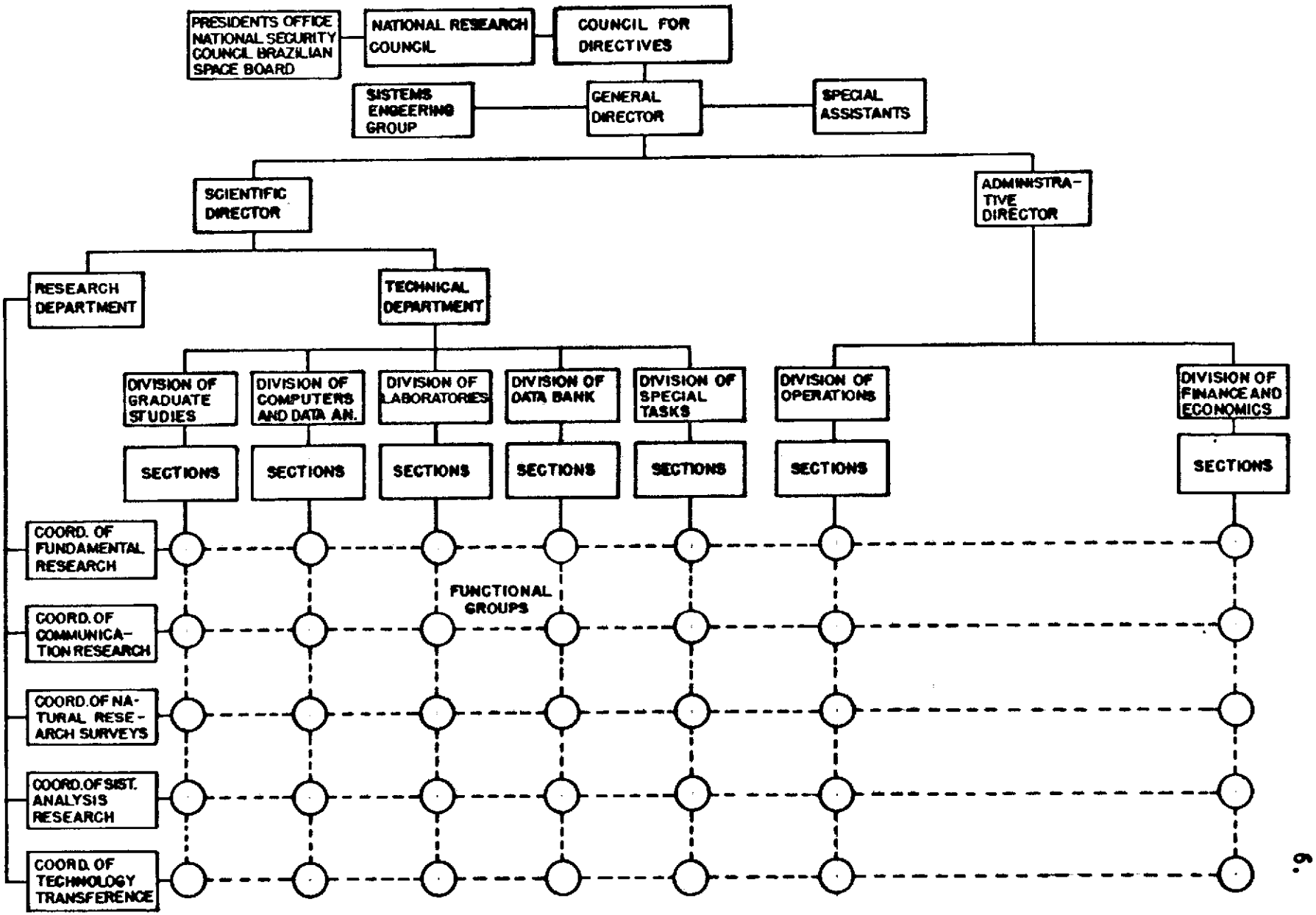
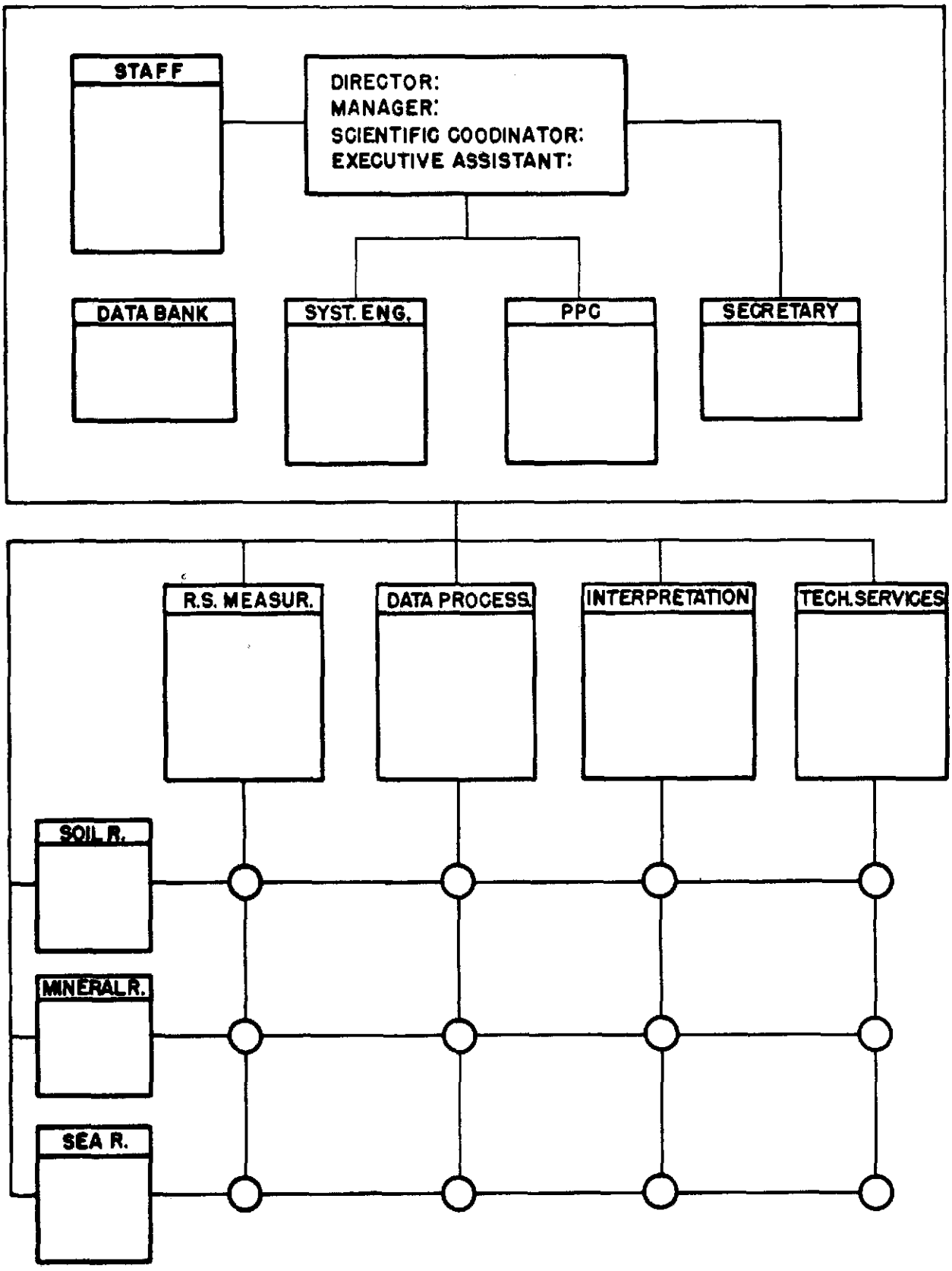


Fig. 1

MATRIX ORGANIZATION CHART
REMOTE SENSING PROJECT



R = RESOURCES PPC PROGRAM PLANING CONTROL R.S. MEASUR = REMOTE SENSING MEASUREMENTS

Fig. 2

. LogEtronic Printing up to 9.5 inches wide.
. Color and black and white enlargement

- Analog/digital data system with the following computers:
  . HP2116B with HP2311C, ADC subsystem with Waltham 56/DA
  . HP2791A, Pacer for high speed action acquisition
  . EAI680 Hybrid
  . B-3500 (Burroughs)
  . B-6500 (Nov. 1971)

4.2 - Our first aircraft (PP-ZCN) is a two-engine, low wing type, modified to carry passive sensor equipment, including the following:

- Wild RC-10 Metric Camera
- Hasselblad 500 EL/70 Four Camera Cluster
- Bendix LN-3 Thermal Mapper (3 to 5 and 8 to 14μ bands)
- Barnes PRT-5 Precision Radiation Thermometer
- Ampex AR-1600 Tape recorder
- Bendix AN/APN 184 Radar Altimeter
- Bendix DRA-12 Doppler Radar
- Bendix M-4C Automatic Pilot
- Time Code Generator. Auxiliar data automation system
- RNA-26C VHF navigation receiver

5. INITIAL RESULTS

Here we will present a summary of the conclusion of our internal publications for the different disciplines of the remote sensing program as mentioned before. These results were obtained from test sites in Agriculture, Geology, Oceanography, Hydrology and Polution.

5.1 - Agriculture

In fulfilment of NASA committments for Phase C, Mission 96 of the Earth Resources Aircraft Program was flown in Brazil during July 1969, utilizing the NASA 927 (Lockheed NP3A) Aircraft.

Concerning to Agriculture, the test sites 801 at Campinas and 802 at Rio de Janeiro were selected. Test site 801, known as "Fazenda Santa Eliza", "Instituto Agronômico de Campinas", has experiments continuously conducted on economically important cultures. As the aims of the mission included problems of identification and classification of vegetable species, it was necessary not to limit the flights to the Experimental farm. So, flights were made over test sites extension lines with extensive plantations of species selected for study.

Test site 802 at the "Instituto de Pesquisas e Experimentação Agropecuárias do Centro Sul" is located at km 47 from Rio de Janeiro and is one of the major organizational units of the Office for Experiment and Research in Agriculture and Livestock of the Brazilian Ministry of Agriculture.

The position of both test sites are shown in Fig.3.

As part of Phase C two other missions were carried out. One of them was "Caratinga Mission" at the State of Minas Gerais in order to study Coffee leaf rust. The other was "Frost Mission" to test the application of remote sensing in the location of different degrees of frost damage at the State of Paraná.

BRAZILIAN TEST SITES

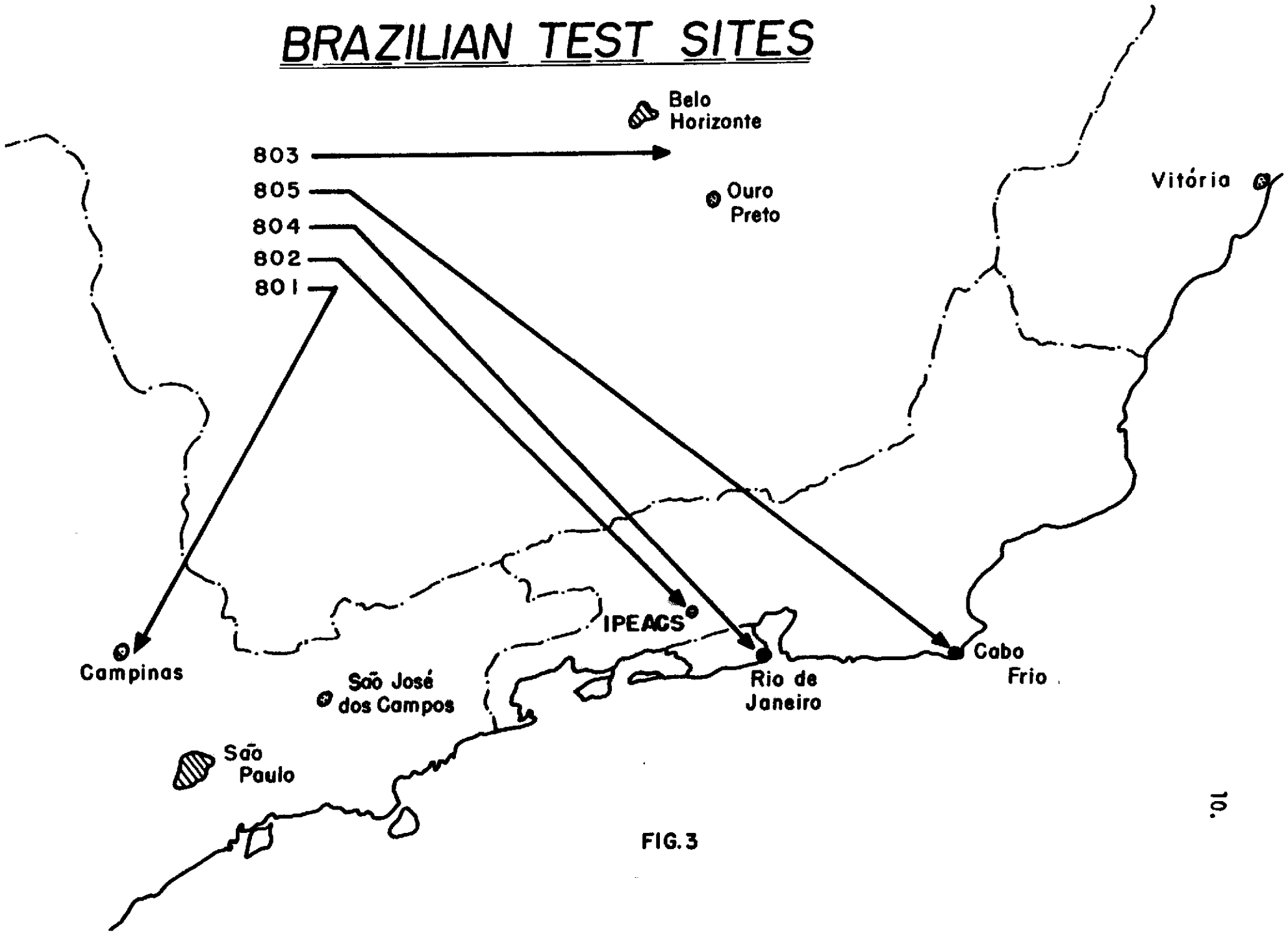


FIG. 3

Test Site 801 - Campinas

Following the January 1970 SERE-NASA meeting at the National Research Council - Rio de Janeiro, a new phase of work has begun to develop fundamental research based upon available equipment and imagery data. Most effort was concentrated on Test Site 801 "Santa Eliza" Experimental Farm in Campinas. Table I shows a summary of results. Eleven research papers have been produced and they are summarized below.

a. "Investigation into the correlation of ground truth light reflectance and image density on colour Ektachrome film".
   - The light density passing through the colour transparency of the Campinas test site at Sta. Eliza was compared with the ground truth assessments for the percentage of light reflectance on the different colour panels during the time of the operational flight.
   - Given the constraints of equipment and resolution requirements of the sampling procedure, the results were very encouraging. There exists a strong correlation between the field results and the image point samples.

b. "Investigation into coffee crop spacing and image densities on colour-Ektachrome & Colour I.R."
   - Some forty plots of coffee (Coffea arabica) laid out at Sta. Eliza experimental farm in a randomised block were surveyed utilizing Colour Ektachrome and Colour-Infrared images. The images of the plots were tested for light intensity, concluding that the crop spacing significantly affected density readings as did the number of

TABLE I

INVESTIGATION SUMMARY - CAMPINAS

TEST SITE 801

INTRODUCTION

Campinas, Site 801, overflown for the scientific disciplines of agriculture and forestry, is in the State of São Paulo, County of Campinas. Its variety of single-type soils,cultures, natural and artificial vegetation, and well-defined seasons of planting provide an excellent aggregate of conditions amenable to comparison and correlation.

SENSOR INSTRUMENTATION

a. Dual-channel infrared (IR) imager
b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR
c. Multiband camera system (KA-62)
d. Side-looking airborne radar (SLAR)

TECHNICAL OBJECTIVES

Agriculture	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Resolve and develop identification keys for crops; i.e., coffee, citrus, sugarcane.		*	
b. Distinguish between red (good) and yellow (poor) soils.		*	
c. Define weed species.	*		
d. Designate various growth stages of sugarcane.	*		
e. Locate noncitrus orchards		*	
f. Classify natural vegetation (trees and shrubs) as mature (dense and open) or as immature (dense and open).	*		
Forestry INCOMPLETE BECAUSE OF OFFSET FLIGHT LINES IN ALL CASES OF INVESTIGATION			*
a. Classify eucalyptus species as mature, immature (dense and thin), and just cut.			*
b. Distinguish between pinus and Brazilian pines.			*

trees per hill.

- However these results were only significant in the case of the Color IR film (at 2.5% level) while with the colour Ektachrome the results were insignificant.

c. "Investigation into image densities for three soil types on colour Ektachrome film"

- Thirteen bare soil areas were surveyed for image density on colour Ektachrome film. The areas represented three types of soil: Red (highly fertile), Yellow (low fertility) and Bog soil (High Organic Matter)
- It was possible, on the basis of densities to separate soils into three groups representative of the three soil types. It is suggested to repeat the study with Colour-IR and the multiband films.

d. "Investigation into the relationship between IR Colour film densities for Coffee plots and yields"

- Fourty coffee plots were surveyed on the basis of light density within each separate plot. The main treatment variations for the plots concerned were spacing variety, height and the number of trees per hill. The relationship between yields and the image densities were investigated. The results confirm the theoretical basis of crop spacing and yield performance on a field rather than plant basis.
- The empirical outcome is that there exists an intermediate density value at which physical yields are higher than those associated with higher or lower density values.

e. "Soil nutrient status studies based on IR-Colour film image densities of coffee plots".

- Fifty-four coffee plots (Coffea arabica) were surveyed on the basis of IR image densities. The coffee surveyed had undergone a series of fertilizer treatments as a part of the regular research activities of the Campinas Agronomic Institute. Use was made of the variations in image density to isolate the main relationships with both soil fertility and coffee yield. The results indicate a capacity to discriminate low nutrient soils from high nutrient status soils with case. The overall relationship between the intensity and yield was also traced and proves to be of great utility in defining the parameter of the coffee crop production surface in therms of remote sensing variables.

f. "Remote Sensing imagery as applied to surface ground temperature estimation".

- The surface ground temperature is of fundamental importance, mainly to agronomic and hydrologic fields, considering that the energy balance depends on the heat flux and water evaporation in plants and in soils.
- This paper reports studies done in order to verify the possibility of terrain temperatures, using a light table and temperatures using a light table and transparencies, followed by comparisons with ground temperature measurements.
- A multiband set of imagery, obtained with four KA-62 cameras and Plus-X Aerographic 2402 film, was taken with the following filters: 47 Blue, 477 mμ; 57 green, 530 mμ; 25A Red, 14-8-14μ . An ISCO spectroradiometer was used to obtain readings and the application of

linear regression gave a highly significant correlation coefficient ($r = 0.92^{**}$) for the Infrared Scanner Imagery. On the other hand, the multiband imagery set showed no significant correlation.

g. "Towards a system of primary production assessment and yield prediction using remote sensing techniques".

- It is possible to estimate the Leaf Area Index (LAI) of vegetation on the basis of diffuse reflectance in the spectral band width 0.75 - 1.4 microns. The method provides the basis for the estimation of primary production potential and productivity over large areas of terrain. In the past the assessment of LAI has been characterized by tedious laboratory procedures. Assessments of primary production potential has also involved detailed time-consuming work capable of being executed only in very small areas of terrain.

h. "Tolerance Theory. Plant community distributions affecting remote sensing considerations".

- A basic discussion on the Tolerance Theory was carried on. This theory developed by R. Good in 1931 (" A Theory of Plant Geography", New Phytol. 30:149-171) presents the following basic concept: Each vegetal species is able to grow and to reproduce successfully under limited weather and environmental conditions.
- Vegetal association, the plant community concept,and the influence of man on vegetal life will be considered as well as some practical applications of the tolerance theory.

i. "The development of an improved system of crop boundary & natural vegetation boundary recognition".

- It was previously discussed, based on the plant tolerance theory, that the three major variables relevant to the synoptic view of the environment are:

  (1) Bioclimatic definition of plant community
  (2) Species dominance
  (3) Species homogeneity

- This study develops the actual applications of these three simple concepts to the field of remote sensing.

TEST SITE 802 - IPEACS

Located near Rio (see Fig.3) at the "Instituto de Pesquisas e Experimentação Agropecuárias do Centro Sul" (IPEACS - Central South Agricultural and Livestock Experiment and Research Institute). The IPEACS, also known simply as "KM-47", was established in 1962 and is one of the major organizational units of the Office for Experiment and Research in Agriculture and Live - stock, Brazilian Ministry of Agriculture.

Our technical objectives at this site for Mission 96 was:

a. Construct a soil-type map from photographic analysis of types of vigor of vegetation cover (bog, half bog, humic gley, low humic gley).
b. Classify pasture-land vigor under different levels of grazing, drainage, and infestation.
c. Define citrus species, detect diseased areas and stages of disease.
d. Distinguish between two major varieties of bananas and detect areas of disease.
e. Locate Irish-potato crop, detect diseased areas,and discriminate water-stress areas from water-deficient areas.

We used the following sensors:

- Dual channel infrared imager
- Mapping cameras (RC-8) with Ektachrome
- Multiband camera system (KA-62)

The analysis is still in progress.

Caratinga Mission

The discovery of Hemileia vastatrix (Coffee Leaf Rust) in Brazilian coffee crop in January 1970 presented the opportunity to test the application of remote sensors in locating different degrees of infection. The aim of a dynamic locational system would be to alert authorities when the disease is spreading to particularly susceptible regions so as to enable actions which minimize the effects upon annual production and permits the transition in production to be as smooth as possible.

We used Colour Ektachrome films and Ektachrome IR films and also Ektachrome infrared (35 mm) using several filters were used. Flights were executed at scales equivalent to 1:2,000; 1:4,000; 1:6,000; 1:8,000; 1:10,000; 1:15,000; 1:20,000 and 1:25,000 at various exposures.

Because of the mountainous nature of the test site the whole site was mapped on the basis of aspect and slope. For statistical analysis of film image density only regions of the same aspect, slope, variety, age and spacing were compared.

The colour scale developed for the study proved to be very effective in predicting the usefulness of Ektachrome for discriminating separate effects. Analysis of the ideal scales for the detection of Hemileia suffered from defective reading apparatus. However now INPE has the capacity for repeat analysis using automatic methods.

The Ektachrome IR film proved to be too old for disease detection work, although copying methods showed up nutrient deficiency symptoms in the crop. Ground shots carried out with newer IR film demonstrated that the Hemileia shows up well in "underexposed" photographs and suggests that exposures in Ektachrome IR film are critical. In order to avoid future incorrect IR exposure settings a small tethered balloon system is being made to define optimal exposures at the lowest flight heights and to fly with brackted exposures above this altitude.

Table II shows a summary of results.

TABLE II

INVESTIGATION SUMMARY

CARATINGA - MINAS GERAIS - COFFEE RUST

IN COOPERATION WITH THE BRAZILIAN COFFEE INSTITUTE

This site for the investigation of coffee leaf rust was located so as to include one of the first major foci of the disease located near Caratinga, M.G.

SENSOR INSTRUMENTATION:

b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR

TEST OBJECTIVES

	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Aerial location of Coffee Leaf Rust in the crop on the basis of a colour scale designed specifically for this purpose.		*	
b. Aerial location on Coffee Leaf Rust on basis of false colour IR film analysis.			*
c. Location of Coffee Leaf Rust using false colour IR film at ground level.		*	
d. Design of survey model for rapid location of disease.	*		
e. Analysis of data for definition of optimal operational flight plan (exposures etc.)	*		

Frost Mission - Bela Vista

The July 1969 frost which affected much of the coffee crop of Paranã State presented an ideal opportunity to test the application of remote sensing in the location of different degrees of frost damage. The information could be used to foresee the degree to which specific frosts will lower production, and, to meet this objective, a simple model has been constructed. The model relates the time for recuperation of production to pre-frost levels to the aggregate frost damage measured by remote sensors.

A field data collected convention was developed relating a simple numerical scale to the degrees of frost damage. Data was collected on inter-row crops, spacing, variety, age, and meteorological conditions for the operational flights. The aerial data used were: Colour Ektachrome and also Ektachrome Infrared together with a PRT-5 thermal sensor. Flights were executed at scales of 1:6,000; 1:15,000 and 1:25,000 and both films exposed at 1/300 sec. f.5.6 - the IR film with a wratten 15 filter.

Thus so far analysis has been based on filtered photocopying techniques over the Ektachrome Colour and Ektachrome Infrared film. The final correlations and initial operation of the model awaits this year's production figures from the test site.

Table III shows a summary of results.

TABLE III

INVESTIGATION SUMMARY - BELA VISTA - PARANÃ - COFFEE

IN COOPERATION WITH THE BRAZILIAN COFFEE INSTITUTE

This site was used for investigations into frost damage and nematode infestations in coffee. The location of the test site was between Londrina & Bela Vista, in Paranã.

SENSOR INSTRUMENTATION:

b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR + PRT-5

TEST OBJECTIVES	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Delineate areas damaged by frost on the basis of IR Col. Ektachrome, Colour Ektachrome and PRT-5 data.		*	
b. Estimation of degrees of frost damage within frost-affected zones using same data.		*	
c. Construction of a logic program for automatic analysis of frost effects.		*	
d. Construction of economic model for use of information gained on frost damage in coffee.		*	
e. Preparation of computer programs for automatic analysis.	*		
f. Location of areas of coffee damaged by nematodes using aerial data.	*		

5.2 - Geology

Like the test sites in agriculture, our initial test site for geology was chosen to be a very well known area, namely the "Quadrilátero Ferrífero". This area has been surveyed for sixteen years with conventional methods. By using the sensors listed in Table IV we were able to produce a geological map which matched the existing one made with so many years of work. By using signatures calibrated with known features of the site, we were able to double the surveyed area of the "Quadrilátero Ferrífero". In this additional area we have signatures indicating a huge deposit of itabirite (a quartzite containing micaceous hematite). This discovery is presently being verified. Another interesting result was obtained from almost constant warm-spots indicated in IR photography. These spots corresponded to "canga" (iron ore)deposits. Apparently, since the thermal conductivity of the "canga" is higher than its surroundings, the internal heat of the lithosphere is conducted to the surface by the mentioned deposits showing up very clearly in the IR photos.

Table IV shows a summary of results from Site 803.

TABLE IV

INVESTIGATION SUMMARY - QUADRILÁTERO FERRÍFERO - TEST SITE 803

This geology test site, "Quadrilátero Ferrífero" (Iron Quadrangle), is considered to be one of the richest mineral deposits in the world. The site is located in the northern portion of Minas Gerais State.

SENSOR INSTRUMENTATION:
a. Dual-channel infrared (IR) imager
b. Mapping cameras (RC-8) Ektachrome Ektachrome IR
c. Multiband camera system (KA-62)
d. Side-looking airborne radar (SLAR)

TECHNICAL OBJECTIVES	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Chart soils, rocks, laterite, and color variation of these materials within the area.	* (soils)	* (laterite)	
b. Lay out vegetation and outcrop patterns in the area.		*	
c. Determine regional structure and lineaments and compare with existing geological map data.		*	
d. Determine if hematite, itabirite, canga, and manganese can be identified through diurnal radiometric temperature variances.		*	* (manganese)

5.3 - Oceanography and Hydrography

Using Test Site 805 in Cabo Frio ($23^{o}S$ - $42^{o}W$) in the State of Rio de Janeiro, we began to look for thermal features indicative of the upwelling phenomenon, the Brazilian current boundaries and the coastal circulation. We looked also for means to detect shoal dangerous to navigation and bottom topography. Two research vessels were used for ground-truth measurements.

Thus far we have the following results:

- The infrared scanner shows details in regions of very strong temperature gradients but it is of limited value in regions of moderate gradients.
- The radiation thermometer, on the other hand, does not have two-dimensional coverage but yields reasonably accurate measurements.
- Good bathymetry can be obtained from the visual spectrum if one avoids the problems of pseudo-parallax caused by the variation of sea surface between two successive photographs and partial reflection of the sun caused by the waves. Suspended grains create a sort of haze over the sand banks.
- We were able to distinguish shelf water from the Atlantic central water and from the Brazilian Current water. These features would not be normally detected in a conventional oceanographic cruise.
- We were able to observe sediment distribution along the coast due to ripple currents, and also the outlining of convergence zones by slicks, mainly in the mouth of rivers.
- The analysis showed the relation between upwelling and wind. We have developed computer models for this problem with promising results.

Table V shows a summary of results.

TABLE V

INVESTIGATION SUMMARY - CABO FRIO - TEST SITE 805

Site 805, for oceanography and hydrography, covers an ocean area approximately 1000 square miles off the coastline of Cabo Frio.

SENSOR INSTRUMENTATION:

a. Dual-channel infrared (IR) imager
b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR
c. Multiband camera system (KA-62)

TEST OBJECTIVES	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Define distribution of sea-surface thermal patterns		*	
b. Locate and define possible upwellings in the sea.		*	
c. Establish Brazilian current boundaries.		*	
d. Characterize the near-shore currents.	*		
e. Distinguish extent of bottom vegetation.	*		
f. Delineate shorelines, subsurface topography, and water depths (hydrographic mapping).	*		

5.4 - Geography

There are internal reports of our group which assess the value of remote sensing for geographic applications. A very detailed study of the data collected over our Test Site 804 in Rio de Janeiro was made in which we tried to apply the results considering the site as an urban structure (sociological studies, transit, flood control, etc.) and as an urban site in itself (soils, geology, etc.). The results also indicate the value of the techniques for city management problems and in addition show some so far unknown geological peculiarities.

Table VI summarises the results obtained so far.

5.5 - Hydrology

This research, performed on Site 804 (Guanabara Bay), has been done by the group of National Department for Water Resources and Energy. Pollution problems and parameters related to tides are studied by this group and Table VII shows some results.

TABLE VI

INVESTIGATION SUMMARY - RIO DE JANEIRO - TEST SITE 804

The city of Rio de Janeiro (Site 804) and its adjacent Bay of Guanabara and seacoast areas have been selected to be used for studies in geography and hydrology, respectively.

SENSOR INSTRUMENTATION:
a. Dual-channel infrared (IR) imager
b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR
c. Multiband camera system (KA-62)
d. Side-looking airborne radar (SLAR)

Geography

TECHNICAL OBJECTIVES	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Discriminate between buildings of various types, age, height, and construction.		*	
b. Delineate and identify urban and rural/urban fringe land-use types; that is, industrial, residential, etc.		*	
c. Study of landslide occurrence.	*		
(1) Study relationship between Inselberg (Bornhardt) geomorphology and landslide processes.			
(2) Obtain empirical data on porosity and permeability zoning in residual soils of Inselbergs in relation to zones of landslide occurrence.	*		

TABLE VII

INVESTIGATION SUMMARY - RIO DE JANEIRO - TEST SITE 804

Hydrology

SENSOR INSTRUMENTATION:
a. Dual-channel infrared (IR) imager
b. Mapping cameras (RC-8) Ektachrome - Ektachrome IR
c. Multiband camera system (KA-62)
d. Side-looking airborne radar (SLAR)

TECHNICAL OBJECTIVES	ANALYSIS IN PROGRESS	VIABILITY	
		Positive	Negative
a. Determine, using dye, the vector of water motion during ebbtide in the bay and offshore at the bay mouth.		* (with constraints)	
b. Determine dispersion tensors of surface water (intensity)		* (with constraints)	
c. Test detection and motion of thin waste film on surface waters of the area.		*	
d. Determine if known sources and types of pollution can be detected, delineated, and discriminated as to biological, chemical, etc.			*
e. Characterize sediment deposition and movement at various depths with various film/filter combinations.			*
f. Study points of cool, fresh water inflow into the bay.			*

6. PRESENT ACTIVITIES

We are presently involved with the following activities in remote sensing:

- Improving and expanding our Laboratories (Electronics, Optics, Pattern Recognition, IR Physics, etc.)
- Starting the use of our first aircraft (visual and infrared sensors)
- Streamlining the project's Functional Flow Block Diagram and associate managerial steps.
- Enlarging the in-house interfacing groups to have of the order of ten scientists on each of the major discipline of the project
- Collaborating in the new Amazonian SLAR project of the Ministry of Mines and Energy (RADAM)
- Collaborating with the Brazilian Institute of Coffee in a vast agricultural program
- Collabotaring with the Institute of Agricultural Economics of the State of São Paulo in inventory problems
- Continuing to coordinate and participate in the programs of many of the users agencies.

At the present stage our real emphasis is on training of qualified individuals. Our future as a coordinating agency for activities related to natural resources is very dependent on the quality and caliber of our research group. This group has to operate well beyond the phase of qualitative analysis and the fashionable displaying of of artistic "signatures". We must accelerate the transition into the phase of experimental repeatability, characteristic of a proper methodological approach.

7. FUTURE ACTIVITIES

- Collaborate and participate in the huge task of data reduction and interpretation for the Amazonia SLAR project (RADAM) which covers 1.5 million square kilometers of northern Brazil.
- Instrument our second aircraft extending our capability in the visual and IR into the microwave spectrum within the next two years.
- Study telemetry requirements of the ERTS system for expansion of our TM ground station.
- Collaborate with the United Nations in awarding scholarships to researchers of other developing countries. We maintain a graduate school at our Institute which includes a program for a MS in remote sensing applications.
- Propose experiment to NASA's Space Station Program (EREP)
- Fulfill the Government directives to INPE as presented in the document "Goals and Structures for Government Actions" mainly in which concerns the use of system analysis methodology to remote sensing of natural resources.
- Prepare to make the best use of the experimental U.S. satellites of the ERTS series. Three proposals were forwarded to the NASA Office of International Affairs for investigations using data from the first earth resources satellite, this participation being part of the fourth of D Phase of the Plan of Cooperation between Brazil and the U.S.A. for applications of Remote Sensing.

Our own in-house proposals cover the following disciplines: AGRICULTURE - FORESTRY - GRASSLANDS, to study the viability of scientific uses and economic substitution of the conventional methods of surveying natural and cultural resources by satellite data. GEOLOGY, to study the application of remote sensing for geological and mineral resources survey. OCEANOGRAPHY, to develop a method of bathymetric studies from satellite imagery.

In addition, two other proposals sponsored by INPE were prepared by cooperating agencies namely the Ministry of Mines and Energy and the Brazilian Institute of Coffee of the Ministry of Trade and Industry.

The first being "A Proposal for the Application ERTS-A Data to Resources Analysis of the Amazon Basin" and the second "Experimentation to verify the viability of orbital images interpretation in order to know the physical aspects of the Brazilian Coffee".

With these two proposals, the user agencies are seeking a program of research which will fit in and, perhaps, supplement two present on-going earth resources aircraft projects. They are the Ministry of Mines and Energy, RADAM Project and the Brazilian Institute of Coffee, Photo Interpretation Service Project.

The first is a multidisciplinary project based in a complete aircraft coverage of part of the Amazon Region (1500000 km^2) gathering data with synthetic aperture SLAR in conjunction with limited amounts of multiband aerial photography taken from high and low altitudes, and ground truth, to map mineral, vegetation, soil and water resources. The flights were started June 1st and shall be finished after a period of four months.

The second project is an agricultural project dealing with coffee resources management (inventory, yield prediction, etc.). In both cases there will be correlative data in such conditions that the resultant data from the proposed satellite experiments shall be analysed within short periods of time.

Our Institution will act not only as the coordinating agency, but will have its own discipline investigators working within the users teams and will provide support in the following activities: aircraft flight requirements, including APT meterorological information; photographic processing laboratory; data analysis and information extration, such as densitometry, multispectral projections, computer processing; data receiving, storing, retrieval and distribution center (Data Bank).

Our in-house proposal, besides its scientific specific objectives, aims to keep up-dating our own discipline investigators competence to solve problems arising from a rapid evoluting technology.

8. CONCLUSIONS

This report has described the Brazilian remote sensing program from the point of view of its implementation. It is hoped that our program could be used as a starting model for other developing nations. Economic and cost-effectiveness studies could not be presented here, but additional information on our program is available upon request to our organization.

We are presently organizing a meeting at our Institute with the auspices of the United Nations , for the end of this year,with the objective of studying how similar programs could be implemented in the less developed nations.

9. ACKNOWLEDGEMENTS

I want to thank the cooperation of the member of our remote sensing group, mainly of J.B. Machado, E. Gama de Almeida and L. A. Fobē in the preparation of this report. Thanks are also due to the agencies which participate in Project SERE.