DESCRIPTION OF THE BRAZILIAN PROGRAM
FOR REMOTE SENSING OF EARTH RESOURCES

TECHNICAL REPORT LAFE - 90

by

J. B. MACHADO

July 1969

PR - Conselho Nacional de Pesquisas
Comissão Nacional de Atividades Espaciais
São José dos Campos - SP - Brasil
DESCRIPTION OF THE BRAZILIAN PROGRAM
FOR REMOTE SENSING OF EARTH RESOURCES

by

J. B. Machado

This report contain elements of CNAE's research program
and its publication has been approved by

Fernando de Mendoça
Scientific Director
DESCRIPTION OF THE BRAZILIAN PROGRAM FOR REMOTE SENSING OF EARTH RESOURCES

by

J. B. Machado

Comissão Nacional de Atividades Espaciais (CNAE)

ABSTRACT

This paper briefly describes the significance for Brazil of the large and fast area coverage afforded by the use of aircraft and satellites for Earth Resources Surveys, giving a short explanation of the program structure emphasizing the needs of integration which is to be obtained by the adoption, in our Space Institution, of new organizational concepts and principles and, finally, informs, in a rather summarized way, the kind of elements which are being provided for program implementation.
A rational way to take advantage of an immense region such as the interior of Brazil, with an area of six million square kilometers and two inhabitants per square kilometer, is to develop there the only economic activity which seems compatible with vast, continental and unpopulated land: the one restricted to points, economic activity in limited areas, where the emphasis can be placed on the exploitation of mineral resources, rather than agricultural ones, exploitation developed on such an economic scale as to be competitive, on the world markets, with the production of better located centers. The satellite capabilities of covering large areas of the earth's surface in short times and relatively moderate expenses appear to precisely fit the necessity of a preliminary broad survey of those remote areas. This basic survey will, surely, make it possible to concentrate the use of airborne and ground based conventional methods of prospecting to relatively limited areas.

As for the intermediate land, between the central areas and the ocean, also vast with some two and half million square kilometers but, in contrast, with a population of over eight million people, the remote sensing from high flying orbital platforms as well as aircraft, besides being again instrumental in finding undiscovered mineral resources, or in further exploring presently mineral productive regions, will certainly prove helpful to the economic management of agriculture and forestry on a regional level. The needs for current information on the extent
and type of land use, and on the growth and condition of crops present an almost unlimited demand for the remote-sensed data. The use of orbiting spacecrafts in addition to aircrafts, enlarges fantastically the possible range of valuable data collection, enlargement especially significant in a country where extensive agriculture is predominant and the forests are, in general, huge. The data obtained for the forestry-agriculture specialists will probably be of equal importance to geographers and to planners interested in broad regional developments. And there are, in Brazil, organized efforts aiming toward the solution of economic development problems of immense regions with extremely different characteristics such as the humid Amazon River Basin and the dry Northeastern Bulge.

An example of a very desirable application would be the use of satellite gathered data on soils to help in the change of conditions existing in the "campos cerrados", a type of savanna land found over an estimated area of one and half million square kilometers (400 million acres), both in Central Brazil and the above mentioned intermediate region. Research has shown that the problem is essentially one of high acidity which can be alleviated by adequate application of agriculture limestone and some fertilizer.

Off-shore, along the extensive Brazilian seaboard—almost 4000 nautical miles —, data collected from orbital altitudes could delineate the temperature contrasts that characterize contours of the Brazilian Current, on the east and the south coasts, and of the Falklands Currents, which invade the southern shores during the winter. Up-wellings and sinkings could also be thus located. Besides being relevant for navigation, maritime rescue and meteorology, this information is very important in their correlation with the movement of the sea biological communities, and, consequently, commercial fisheries, the heavily relied source of food.
Up to this point, we tried to present a concise explanation of why we have special interest in satellites for earth resources survey, mentioning some major problems, related to large regions, where a program of studies seems feasible by the utilization of sensors with wide, fast and repeated coverage capabilities combined with limited resolution requirements. Studies which are likely to produce practical benefits for large segments of the Brazilian economy, and to contribute to the well being of large groups of people.

From here on, we will tell something about the program proper.
PROGRAM STRUCTURE

Research Program

This brief information is designed to acquaint the reader with the research program which is being conducted by the Brazilian Space Agency (CNAE) with the cooperation of the U.S. National Aeronautics and Space Administration, on remote sensing of natural and cultural resources from high flying platforms, presently, from aircraft and, in the future, from artificial satellites. It is not the purpose of this paper to discuss the technological or scientific aspects of the problem.

We must begin with a few words about our organization, the designated agency for implementation and coordination of the Earth Resources Remote Sensing Program in Brazil and about the cooperative program we have with NASA, in association with other Brazilian and United States research groups, the purpose of which is, in brief, to develop techniques and systems for acquiring, interpreting and utilizing earth resources data from aircraft in order to determine the potential utility of spacecraft applications of these techniques.

CNAE (Comissão Nacional de Atividades Espaciais) is a space science oriented Brazilian Government institution, located in São José dos Campos, in São Paulo, with over 128 researchers, in 1969, of whom 23 are going through their doctorate in the United States and France. This group was started in 1963 and plans were made to reach 1972 with 60 PhD's, 140 MSc's and 300 supporting persons.

The cooperative program in remote sensing has been divided in four phases which are:

PHASE A - Cooperative training program in the U.S., with the participation of Brazilians, Mexicans and Americans, which took place last year, during a period of six months.

PHASE B - Program development including the selection and development of test sites in Brazil by Brazilian User Agencies, the procurement of the instrumented Brazilian aircraft, and the establishment of a data processing and
reduction center and data bank by CNAE. This phase started in November 1968 and will last until the Brazilian aircraft becomes operational.

PHASE C - NASA aircraft flights over Brazilian Test Sites. These overflights occurred during the first quarter of July, this year. To Brazil the resulting data of these flights will have special significance, they will help us in deciding the desirable configuration of our aircraft-sensor system.

PHASE D - Operational Flight by Brazilian Aircraft.

No exchange of funds is contemplated between the two cooperative groups. Each side is bearing the costs of discharging its respective responsibilities.

All data acquired by aircrafts or spacecrafts, in the course of the joint program, which will last up to January 1st 1971, is being made available to both groups. Primary responsibilities for the analysis of data residing in general with the group over whose national territory the data were obtained. However, if either party should identify data of economic significance concerning the territory of the other, such data is to be brought immediately to the attention of the other party. The scientific results of the program are to be made freely available to the scientific community.

Integrated Research

In the following comments, it is intended to give a very concise explanation of our organisational structure.

Instead of the traditional line and staff type of organization, our space agency is using a matrix organization, in the sense of systems engineering, to assure adaptability and flexibility to a system for which the objectives are subjected to extremely changeable scientific and technological factors. In this type of organization, a well established set of basic functions—the functional divisions—work only in a support rela-
tionship to the different projects being developed. In other words, the functional divisions exist to provide functional personnel groups to line projects and give support assistance to those groups.

The line projects, in a matrix organizational chart, may be graphically shown by the respective functional groups, horizontally aligned by specific project with these project functional groups vertically located under the functional divisions from which they originated. Each project line organization composed of a manager and the necessary functional groups, receiving, through a web of relationships with the functional divisions, support assistance, such as policy guidance, technical advise and help, administrative services, etc.

Additional projects may be easily added, and as completed or phased out projects are excluded from the organization, the managers and functional group personnel return to the original support division for reassignment to new tasks or training.

In the Organization Chart, at the end of this paper, appear the functional groups which are being used by the management of the program to attain what is considered the ultimate aim of all the work which is being done by our Agency. This aim may be stated as:

"To build continuously and systematically, to the maximum degree and in the proper proportions, that knowledge and those technical capabilities which are believed to be new contributions to the development of the application disciplines."

This aim of complete and continuous improvement cannot obviously be achieved through sporadic, unrelated, dispersed efforts. The full benefits will be gained only if the program is so integrated as to direct every individual researcher, every interested group, every method and technique toward the accomplishment of that ultimate aim. Without such integration the efforts
the translation of these aims into specific objectives in the different fields of application. Such a committee should include representatives from the user agencies of sufficient stature to speak authoritatively for their agencies. Further practical means of integration is the long-range planning. Through this means the program is integrated in terms of both over-all purpose and specific objectives.

Moreover, to meet this integration need of planning, education must be deliberated and planned. It cannot be left to chance in the hope that men will somehow select out of the multitude of choices confronting them, those knowledges that will best equip them for complete, useful and harmonic working within the program. This is specially true in well defined research in applied science as happens to be the case.

A final device for integration on the level of the individual researchers or research teams is the individual or team progress measurements through systematic requirements of progress reporting to a planning and control office for the program. Since, exactly how much follow-up is to be required depends on the nature of the specific research job, follow-up emphasis may be placed only on cases of outstanding results or difficulties, instead of tedious routine reports.

Elements for program execution

As for human elements on-hand and additional requirements for program execution, we may inform that, working at our institution for the Remote Sensing Program, we have, at the present moment, a group of 20 people consisting of engineers, physicists, cartographers and meteorologists, of whom 4 electronic engineers went through the six months training program organized by NASA.

Our earth resources investigating groups are constituted by agriculture and forestry specialists, geographers, geolo-
gists, hydrologists and oceanographers, organized by the User Agencies in special project-teams for the disciplines they are interested. Of these groups, at least one of the specialists in each field, went through the above mentioned six months training program.

In view of this broad responsibility of coordination of work being done in several different field of application and of the necessity for maintaining adequate channels for an exchange of ideas on progress and program development between Brazilian user agencies, our own space agency and their foreign counterparts, our internal system includes a functional group of mineral, marine and agriculture resources specialists, working as an interface group belonging to CNAE, and is being helped by specialists involved in meteorological and geodetic research projects which are also being conducted at our laboratories.

In addition to the responsibilities of general program coordination and of acting as a know-how transfer and fixation agent, by local parallel contribution to the new technology, and in accordance to this latter responsibility CNAE is required to provide and to operate the physical facilities for data acquisition which are peculiar to the earth resources remote sensing program or which are not yet of current use in the field of aerial surveying.

This signifies, in addition to the procurement of laboratory and field instrumentation, the assignment of a suitable aircraft to the program, fitted with the selected remote sensors and the required complementary equipment.

It is recognized that the size and capability of the aircraft can be adequately determined in part by test sites location and character and in part by instrumental load. In the selection of the optimum instrumentation, we believe that it will be prudent to consider a number of conditions and circumstances attendant to this choice and attempt to establish certain selection criteria.
Some sensors represent a substantial development effort by the manufacturers, and therefore any quotation offered to us would, of necessity, include the cost of this effort. Further, these instruments and their associated equipment are rather complex and we believe that very special care in its maintenance and operation would be required. We also believe that spare parts (and some are very expensive) necessary to maintain the instruments over a reasonable period of operation should be obtained at the time of the instrument purchase.

When a technology is still in the phase of early development, it seems risky to invest considerable amount of money in elaborate equipment related to it, on the other hand we cannot expect to find full operational and low-priced new instrumentation for specific use in a changing technology.

Obviously, a compromise has to be worked out on the basis of the available funds.

It is advisable to design and build, in Brazil, simple remote sensors for economic reasons as well as for providing a sound basis for the development of local know-how.

Attention should be paid to obtaining a balance between the data collection and processing and the analysis and interpretation capability of the users.

In the case of Brazil, the airborne sensing should not be looked upon merely as an experimental step toward orbital sensing; efforts should be directed to ensure a practical utilization of the collected data.

Finally, the system must be such that the of-necessity large initial investment stays within levels compatible with the available funding and talent.

The decision to shift the Brazilian Test Sites overflights by NASA remote sensing aircraft (Phase C of the cooperative program) to the middle of the material implementation phase (Phase B) brought about an opportunity to test the significance of most of the above remarks, before taking final decisions re-
garding physical facilities for data acquisition.

In view of the great volume of remote-sensed data which would be collected, particularly during the orbital-sensing phase of the program, it is recognized that its adequate processing, storage and dissemination are most important problems which require careful consideration and planning. Of equal importance is the need to develop an automatic data interpretation capability. For handling these requirements, CNAE is completing its own electronic data processing center, is procuring a high quality photographic processing laboratory and is establishing a careful planned data bank.

Since CNAE is not a service organization, these facilities will be provided to the user agencies until the usefulness of the new techniques have been well demonstrated and accepted. However, in order to provide a long range coordination, CNAE will continue to perform some research in areas associated with the program.