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1. INTRODUCTION

Given the vast dimensions of the country with large areas of difficult access, the extremely uneven distribution of its population, the dynamic character of the processes that take place on its territory, and the amazing difficulties in reaching — and thus observing in loco — large areas of great economic, strategic and scientific interest, it is no wonder that one of the most important developments of the space age for Brazil has been the potential generated by space remote sensing programs and techniques. Territory integration and the necessity of obtaining low-cost, reliable and periodic information about it were the key factors responsible for the large utilization of data collected and/or transmitted by application satellites.

Consequently, Earth observation satellites which allow the periodic survey of large areas very rapidly and at relatively low cost became an effective tool for Brazil to increase the knowledge about its renewable and non-renewable resources and environment. Additionally, the only possible way to provide domestic communication for the whole country is through the use of satellites.

Brazil was one of the first nations in the world to join the Landsat program, installing a receiving station in Cuiabá, Mato Grosso, at the geodetic center of South America and a processing station in Cachoeira Paulista, São Paulo. Today both MSS and TM data

from Landsat 4 and 5 are routinely received and processed at INPE's facilities. Modifications on the stations to receive and process SPOT data have already been programmed to occur in a very near future. Brazil is presently one of the world's largest producers and users of Landsat images, with more than 1500 entities subscribing to and depending on Landsat data for the most varied applications.

In 1979 the Brazilian Government accepted the challenge to carry out a small but ambitious Space Mission, tuned to the country's modest means, but in keeping with its unbending desire to close the gap between it and the most advanced nations in the world. Proposed by the Brazilian Committee on Space Activities (Comissão Brasileira de Atividades Espaciais - COBAE)*, the Brazilian Complete Space Mission - MECB, as it became known, calls for the design, manufacturing, launching and operation of four satellites, and is to be completed in the early nineties. While the first and the second satellites will be devoted to relay environmental data transmitted by an array of data collection plataforms (DCP), the third and fourth satellites of this Mission will carry a Remote Sensing camera.

The wisdom of this decision seems to be confirmed by the distinct and, in retrospect, inevitable trend toward commercialization of all current programs in the developed countries.

A major step towards the preparation of the satellites for the Brazilian Complete Space Mission is the expected flight on NASA's Space Transportation System of a Brazilian Remote Sensing Experiment - BRESEX - in 1987.

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* *COBAE is the government agency responsible for space activities in Brazil.*

The great technological success of the United States Space Transportation System, and the opportunity offered by the President of the United States to the President of Brazil to participate in a cooperative experiment with NASA, have introduced a perfect chance to use, in space, a prototype of the imaging instrument to be used in the Brazilian satellites and evaluate its design parameters prior to the launch of the satellites themselves. The possibility of flying an early version of the CCD Multispectral Camera on the Shuttle greatly motivates INPE's team of development engineers, much increases their confidence of ultimate success, and enhances the capabilities of accurately determining optimal specifications for the hardware that will have to accomplish the goals of the Mission.

The basic objectives of the Brazilian Remote Sensing Experiment (BRESEX) which should fly on the Shuttle probably in mid 1987, are thus to develop a prototype of the instrument that will, four years later, fly in the Brazilian Remote Sensing Satellites, to use this instrument on board the Shuttle to obtain data over Brazil in the greatest possible variety of conditions (time of day and off-nadir specially); and to help freeze specifications on the final Satellite instrument. These objectives, with their clear implications for the Brazilian Complete Space Mission, are listed in Table 1.

2. TECHNICAL CONSIDERATIONS AND DESCRIPTION

Given the limitations of the launching vehicle, the aim is to develop an instrument with maximum performance but not much heavier than 30kg, bulkier than 30dm^3 and not requiring much more than 30W power to operate. Clearly CCD push-broom technology must be adopted, especially considering that the spectral bands identified so far as most appropriate for the targets of interest fall within the range of the silicon-based technology mastered today. Maximum resolution, swath-width, the spectral bands, radiometric sensitivity, raw data rate and such technical specifications for BRESEX are listed in Table II. These specifications are still subject to some change, and are fully consistent with present thinking on the aim of the Brazilian Complete Space Mission: at the higher orbit (~600km) foreseen for this Mission, resolution would be proportionally reduced, and the swath-width increased. Most other parameters would be little affected, except through the results of the Shuttle Experiment, of course, and in the expected lifetime of two years for the Satellite Missions. The expected BRESEX schedule is presented on Table III.

A breadboard model, assembled in the course of the development of the electronic concept of the Multispectral Camera, using a Hasselblad lens and non-optimized structural mounting, was tested in February 1984 on board a Bandeirante aircraft. In spite of analog recording of the data on High Density Tape and the absence of pitch/roll/yaw compensation — the instrument was firmly anchored to the floor of the aircraft, and no navigational data could be recorded for geometrical image correction on this ocasion — the quality of the pictures obtained was quite encouraging, with only some rather minor line to line synchronism problems. The data were obtained from an altitude of 10000 feet, at an airspeed of approximately 360km/h, near local noon, the nominal ground resolution being 75cm, swath-width 1.3km. A Fairchild 1728-element CCD 122 linear array was used in this one-channel version of the instrument, the spectral band chosen being defined by one of three interference filters mounted on a rotating drum.

TABLE I

BRESEX OBJECTIVES

- To develop a Multispectral Camera (MC) for resource observations using solid-state linear array technology, with specifications as close as possible to those needed to attain the goals of the Brazilian Complete Space Mission/Remote Sensing.

- To evaluate the performance (spatial, spectral, and radiometric resolutions and geometric characteristics) of the Multispectral Camera for the characterization of specific aspects of targets associated with agriculture, geology, soils, hydrology, land use and vegetation, in different physiographic regions of the Brazilian territory.

- To evaluate the impact of the higher spatial resolution of the Multispectral Camera in the lower Shuttle Orbit in the discrimination of determined targets of the Brazilian scenario.

- To investigate the effect of non-conventional time of the day for data acquisition on the radiometry of the scene (similar test-sites at different locations is acceptable) so as to help freeze orbit specifications for the Brazilian Complete Space Mission.

- To study radiometric effects of images taken off-nadir, taking into consideration the geometry and composition of the scene so as to determine optimal use of side pointing capabilities in the Brazilian Complete Space Mission.

TABLE II

BRESEX TECHNICAL SPECIFICATIONS IN CONTEXT OF THE COMPLETE BRAZILIAN SPACE MISSION

- Instrument type: - Push-broom multispectral imager using CCD line array technology
  - ±15° side pointing flat mirror for cross track imaging
  - Field-of-view on ground: 40km-swath at 300km-altitude
  - Resolution: 20m at 300km altitude
  - Radiometric sensitivity: ≤1%
  - Encoding: 8 bits/pixel (256 gray levels)
  - Spectral bands: Band 1:0.47 - 0.53μm
    Band 2:0.63 - 0.68μm
    Band 3:0.83 - 0.91μm
  - Raw data rate: 18 Mbits/s (for 3 bands)

- Lifetime: - Up to 7 day missions and option to redesign for operational 2 year mission

- Carrier: - Shuttle (1987); operational Brazilian Remote Sensing Satellite (1991, 1993)

- Flight parameters: - about 300km maximum height, circular orbit for Bresex 28.5° inclination (ideally)

- Center and Manufacturer: - Instituto de Pesquisas Espaciais (INPE) and subcontractors presently being defined

- Status: - Instrument design underway; pre-prototype tested in airplane.

TABLE III
SUGGESTED BRESEX SCHEDULE