1. Classification *INPE-COM.9/RRE*	2. Period	4. Distribution Criterion internal [ ] external [X]
3. Key Words (selected by the author) *LANDSAT SYSTEM* *ERTS SYSTEM* *BRAZILIAN LANDSAT SYSTEM*		
5. Report No. *INPE-1143-RRE/033*	6. Date *October, 1977*	7. Revised by *Jorge de Mesquita*
8. Title and Sub-title *SOME RECOMMENDATIONS FOR THE IMPLANTATION OF A LANDSAT SYSTEM BASED ON THE BRAZILIAN EXPERIENCE OF CNPq/INPE*		9. Authorized by Parada *Nelson de Jesus Parada* *Director*
10. Sector *DPR*	Code	11. No. of Copies
12. Authorship *José Luiz de Barros Aguirre* *Márcio Nogueira Barbosa* *Sérgio de Paula Pereira*		14. No. of Pages *48*
13. Signature of first author Marcio Nogueira Barbosa		15. Price

16. Summary/Notes

INPE's experience during the last five years, with the installation of its LANDSAT system, is described here in order that other countries may profit from it, should they decide to install their own systems.

17. Remarks *Prepared for the LANDSAT Ground Station Operations Working Group - Sioux Falls, South Dakota - USA - October 27/29, 1977.*

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1 - INTRODUCTION

The installation and operation of a system for acquisition, processing and distribution of LANDSAT data in developing countries as Brazil is, undoubtedly, one of the most arduous tasks, if we consider:

- The sophisticated technology existing in the system;
- The technical capacity demanded for normal operation and system maintenance;
- The difficulty for obtaining large quantities of consumables and spare parts in the internal market;
- The need of fast start-up operation due to political exigencies and to demand by researchers and data users;
- The technical quality of the system products, required by the users.

INPE's experience during the last five years, with the installation of its LANDSAT system, is described here in order that other countries may profit from it, should they decide to install their own systems.

As a matter of fact, the solutions adopted by INPE, as well as the recommendations presented here, may not be the best ones for others but, certainly, will be valuable for the solutions of similar problems.

This document is not intended to be exhaustive, but will only analyse the problems that caused most trouble during the implantation phase.

We intend to elaborate, in the future, another document similar to this one, with recommendations in the operation area.

2 - INSTALLATION

2.1 - IMPLANTATION PHASES AND BRAZILIAN SYSTEM FUNCTIONS

In Figure 1, the implantation phases of our system, as well as the times before beginning operations of each sub-system, are presented through a chronogram, which shows:

- reception and recording;
- electronic processing;
- photographic processing;
- distribution.

For each phase, recommendations which will help securing good performance are presented.

And, to give an idea of the principal functions of the Brazilian system, we present, subsequently to the chronogram, block diagrams of the receiving and recording and electronic processing sub-systems.

Briefly, the principal functions of each sub-system are:

a) Receiving and Recording

- Receiving and recording, in real time, of MSS, RBV and PCM signals from any satellite of the LANDSAT series, through the Cuiabá Station. The recorded data are sent by air freight, to the Processing Laboratories, in Cachoeira Paulista;
- Recording of images in real time or off-line, through a Quick Look Monitor, in a 70 mm B & W film, of any channel of the MSS or RBV sensors.

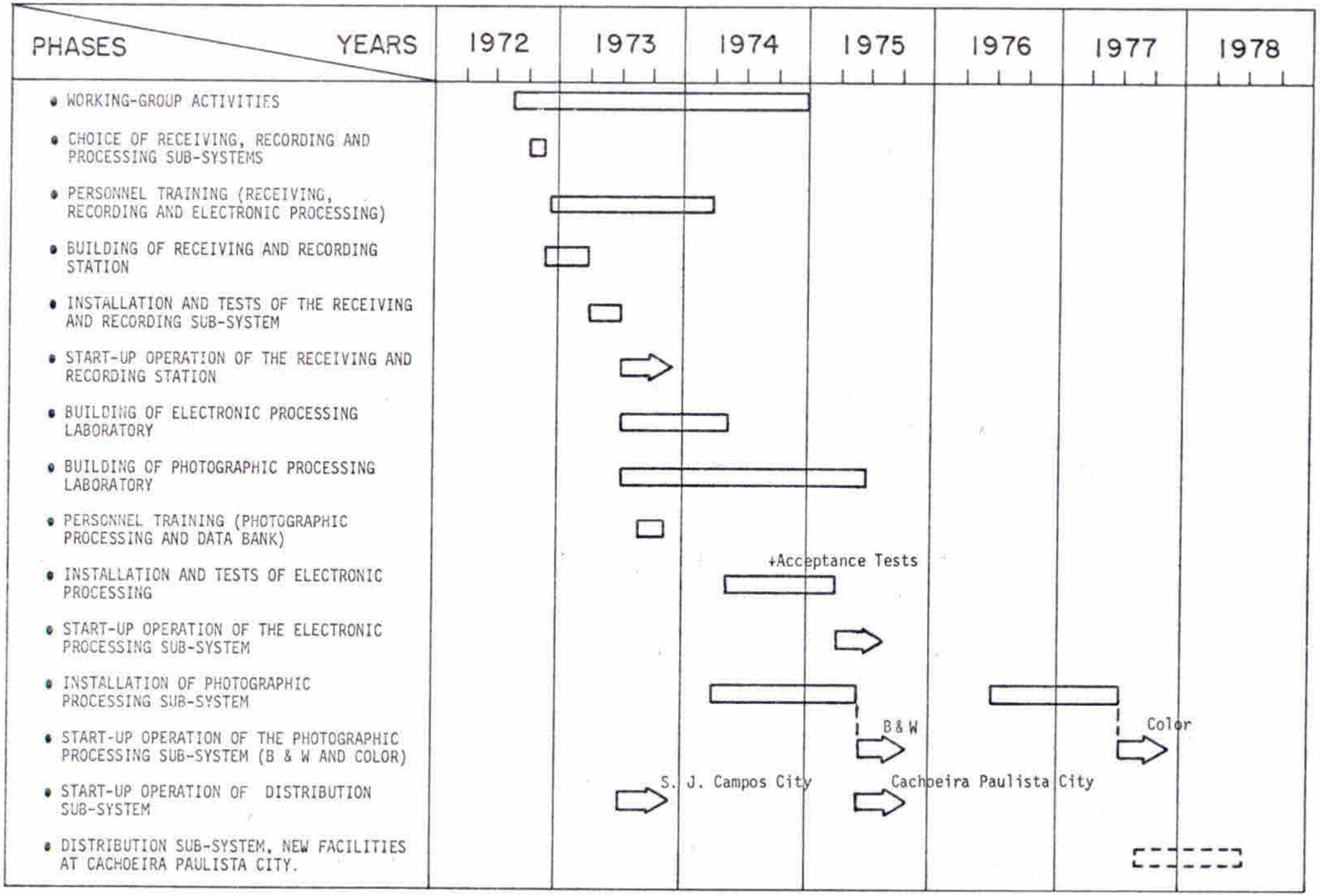

Fig. 1 - Chronogram of Implantation for BRAZILIAN LANDSAT SYSTEM

b) Electronic Processing

- Processing of the signals recorded in Cuiabá Station for the generation of 70 mm B & W films, which contain the several channels of a given sensor (MSS or RBV);

- Processing of the recorded MSS signals, for the production of computer compatible tapes (CCT's), in 9 tracks with 800 bpi;

- Visualization, in a colour video terminal, of any required pass of the satellite, as recorded in video tape or CCT, for control and research purposes;

- Processing of precision images (not yet used on an operational basis).

c) Photographic Processing

- Photographic processing of the original film of LANDSAT data, generated by the electronic processing sub-system, for the generation of the following products for users:

(sc. 1:3.704.000)	nominal 70 mm	- positive or negative transparency in B & W;
(sc. 1:1.000.000)	nominal 9 1/2"	- positive transparency and paper (colour and B & W);
(sc. 1:500.000)	nominal 20"	- paper (colour and B & W);
(sc. 1:250.000)	nominal 40"	- paper, B & W;

- Photographic processing of several products in different presentations and sizes for support to INPE's Remote Sensing Program, such as:
  - images from SKYLAB missions;
  - images from air surveys;
  - photo-mosaics in general.

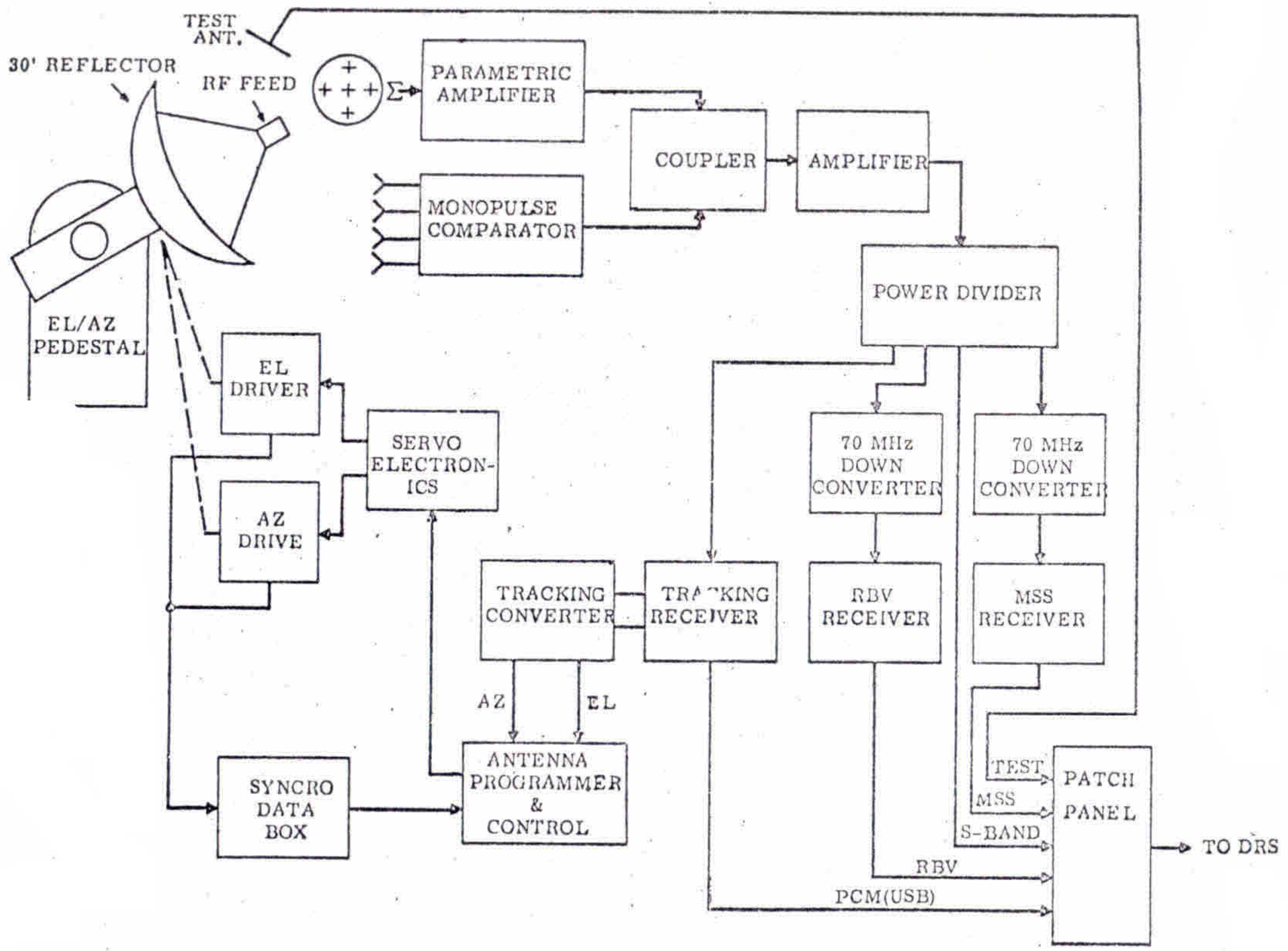

Fig. 2 - INPE Telemetry & Receiving Sub-system (TRS) - Block Diagram

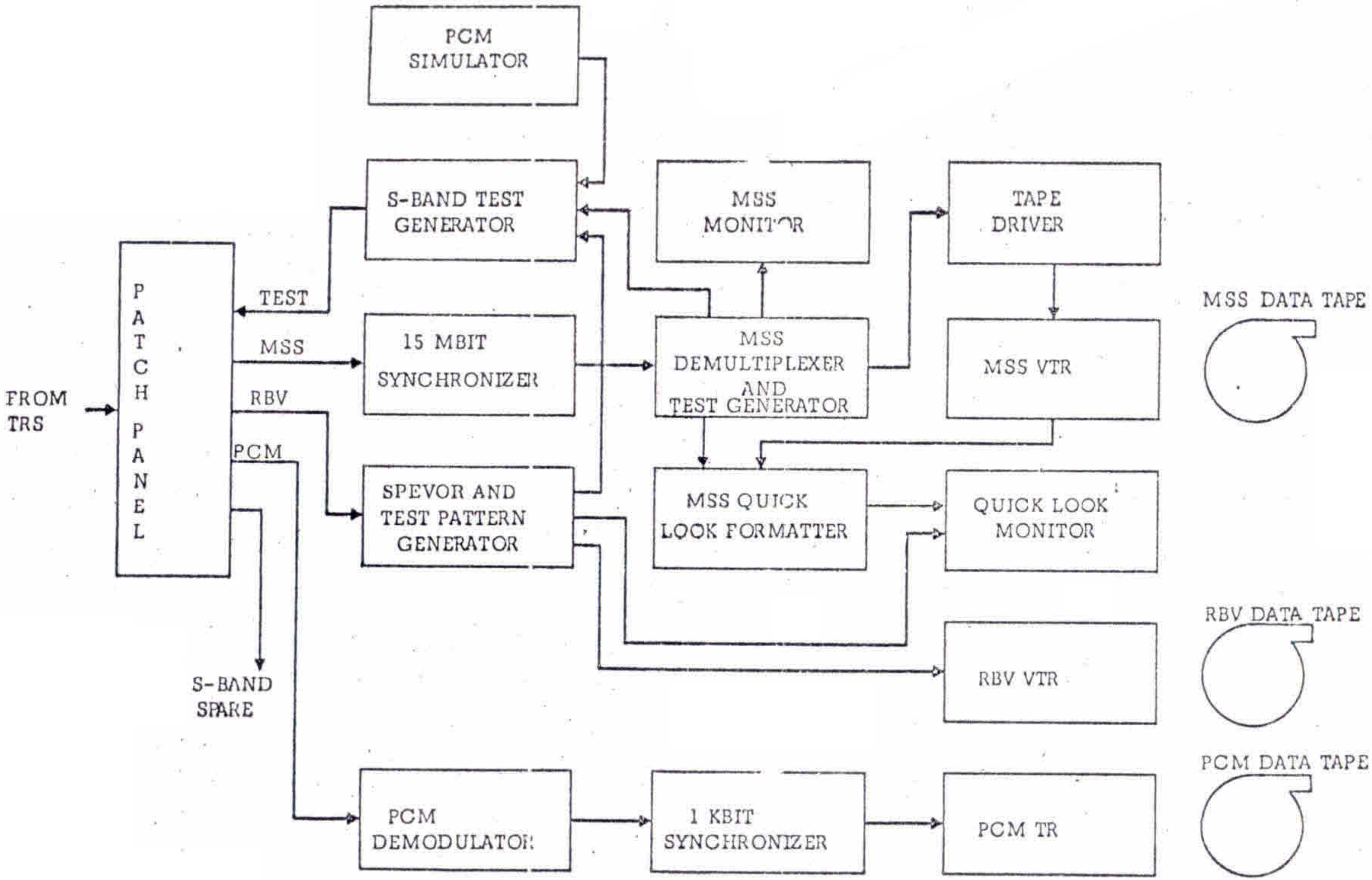

Fig. 3 - INPE Data Recording Sub-system (DRS) - Block Diagram

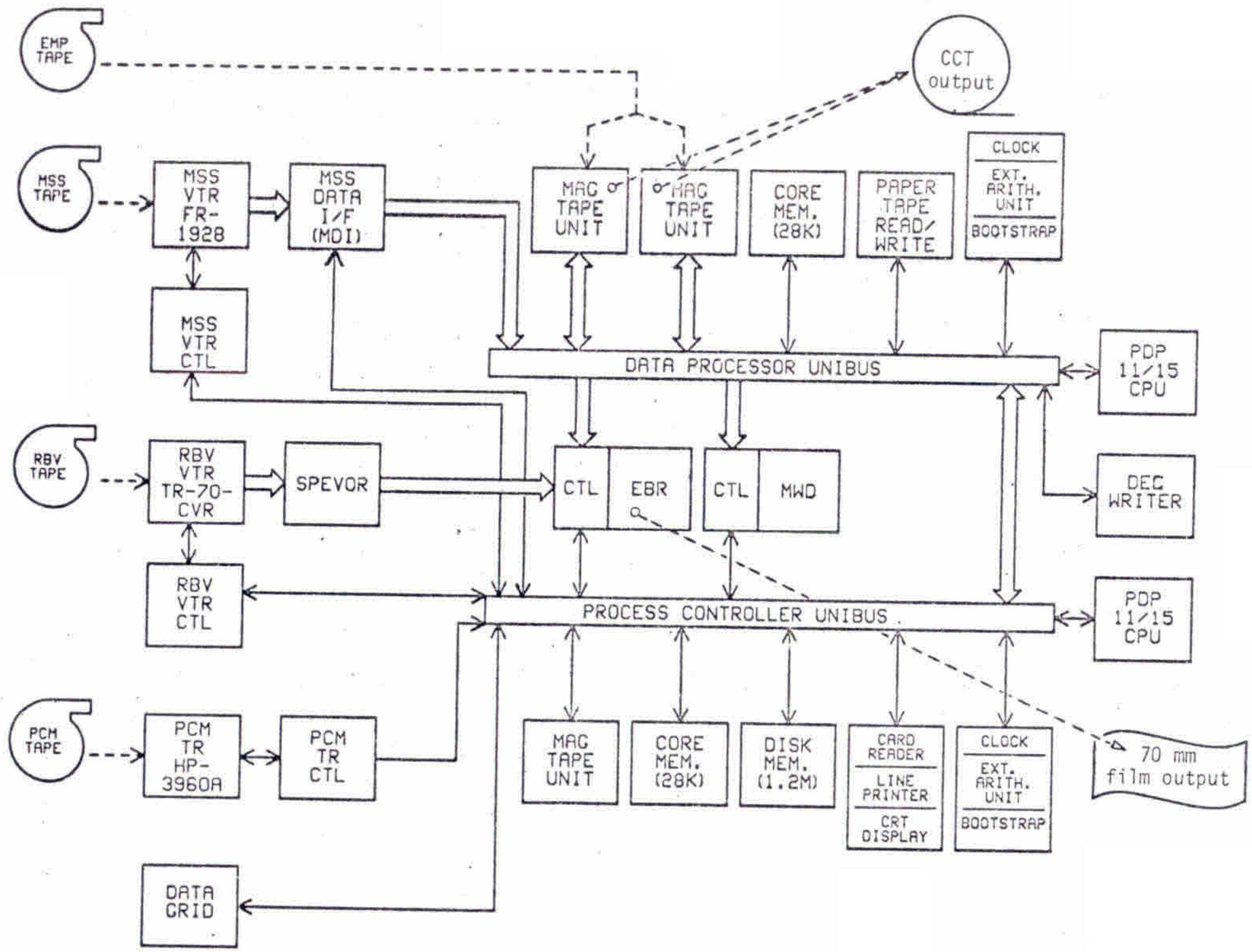

Fig. 4 - INPE Electronic Processing Sub-system (EPS) - Block Diagram

d) Distribution

- Distribution, to internal users from INPE, Brazil and exterior, of LANDSAT and SKYLAB data and also air surveys effected by INPE, with emphasis on LANDSAT type products;

- Storage of all the original films of LANDSAT and SKYLAB data and of air photos existing in INPE;

- Storage of all the tapes recorded in Cuiabá Station;

- Support to users in general in the access and retrieval of data and information in connection with the Remote Sensing Program.

2.1.1 - FORMATION AND ATTRIBUTIONS OF THE WORKING GROUP

The establishment of an interdisciplinary group, responsible for the implantation of the system is fundamental because, with the combined opinion of experts from several areas, decisions on problems should be more efficient.

This working group in INPE lasted 2 years and a half, due to internal administrative needs, although it probably should have lasted until the Photographic Laboratory started operations.

The choice of the working group members is quite important, once that the proper constitution and performance of this group will reflect on the good development of the tasks. We can divide the persons of the group into two classes:

- Operation Technicians;

- Support Technicians.

"Operation Technicians" are the ones who will analyse technically the supplier's proposals; they will also receive training for key positions which they will fill when the system is in operation.

"Support Technicians" are the ones who will act as consultants to the leaders of the group in administrative, financial and juridical matters, chiefly during the implantation phase.

For operation technicians, we recommend:

- 2 (two) electronic engineers with experience in telemetry and telecommunications and in computer science (hardware and software). They will be able, after training, to head the Receiving and Recording Station and the Electronic Processing Laboratory;

- 1 (one) photographic engineer with experience in automatic and manual processing of black-and-white and colour (both films and papers) also competent in sensitometry and chemistry. If there are no experts with such a background, a technician experienced in aerophotogrametric data processing may be trained for this function. He will be able, after training, to direct the Photographic Laboratory;

- 1 (one) computer engineer with experience in Data Bank. He will be able, after training, to direct the Distribution Center.

For support technicians, we recommend;

- 1 (one) economist with experience in the elaboration and follow--up of budgets, finances, imports and purchases;

- 1 (one) lawyer as consultant to the leaders of the group in the drawing-up and analysis of contracts for the purchases and maintenance of the equipments, besides the contracts for civil construction work;

- 1 (one) architect to coordinate and inspect the activities of the building and civil engineering contractors, checking on lay-outs, environmental aesthetics and functionality of the sectors. He could be responsible, with the help of engineers and project men, for the design itself, if this be required.

- 1 (one) mechanical/electrical engineer to control any special installation, such as air conditioning, hot and cold water, compressed air, low temperature chambers, alarms, fire prevention systems, etc.

Finally, we recommend, as the group leader, an engineer, preferably electronic, experienced in project administration and system analysis, with direct access to the highest Head of the organization.

The "lifetime" of the working group should be determined when planning for it, that is to say, its beginning and end should occur in precise dates.

- beginning - as soon as the highest Head of the organization decides to implant the system, and

- end - after the successful acceptance tests of all the sub-systems.

2.1.2 - CHOICE OF THE RECEIVING, RECORDING, ELECTRONIC PROCESSING AND PHOTOGRAPHIC PROCESSING SUB-SYSTEMS

Lack of experience with production systems, common in research organisms like INPE, caused some important details to be over--looked and even not to be considered in analysis phase of the proposals. Besides, in the case of the sub-system of photographic processing, there was no integrated proposal to be analysed, because the sub-system was assembled as resources became available in each period, that is to say, the necessary equipments were being purchased piecemeal. Nevertheless, it will also be commented upon.

The first concern in the choice of a system like this, must be the analysis of the approach taken by the supplier or suppliers. Two such approaches are possible. The system (and more specifically the sub-system of the electronic processing) is either research oriented or production oriented. Even in the case of a research organization, our opinion is that the system must be production oriented, that is to say, capable of the largest output in the least possible time. At first sight, the installation of a "factory" within an organ of research may seem contradictory but, if we consider the technical capacity demanded to operate and maintain the system and the involved technology, there will be no doubts.

The need for a production oriented system will only become apparent with the demand of an ever increasing number of users requiring more and more products; certainly, this increase will be impressive. In Brazil, in the first years we had only three large government users; in the second year there were fourteen and today, in the fifth year of experience, we have already over two hundred users of all types, with nearly half of them belonging to private companies, and the trend is still on the rise. Our system, for this reason, has required several modifications to face such increase in production and demand.

If the site chosen for the installation of the Receiving and Recording Station, for reasons of adequate area coverage (see Figure 5), is far from the Processing Laboratory, the existence of equipments for controlling the quality of recording is fundamental. In this case, a quick-look image recorder (see Figure 6) is quite efficient, even though one may think that these images are products of a quality inferior to the ones generated by the electronic and photographic processing laboratories. For future ease of handling and control of these images, this recorder may be furnished with a character generator for annotation and gray scale. We should also remark on the convenience of the quick--look module allowing use of a Polaroid camera for faster response to quality checks.

The satellite tracking system must have the possibility of automatic and programmed tracking (through perforated paper tape or equivalent). The main objective is the normal recording of the overhead part of the trajectory without loss of sinal. Normally, this is possible only through programmed tracking due to limitations of the turning speed

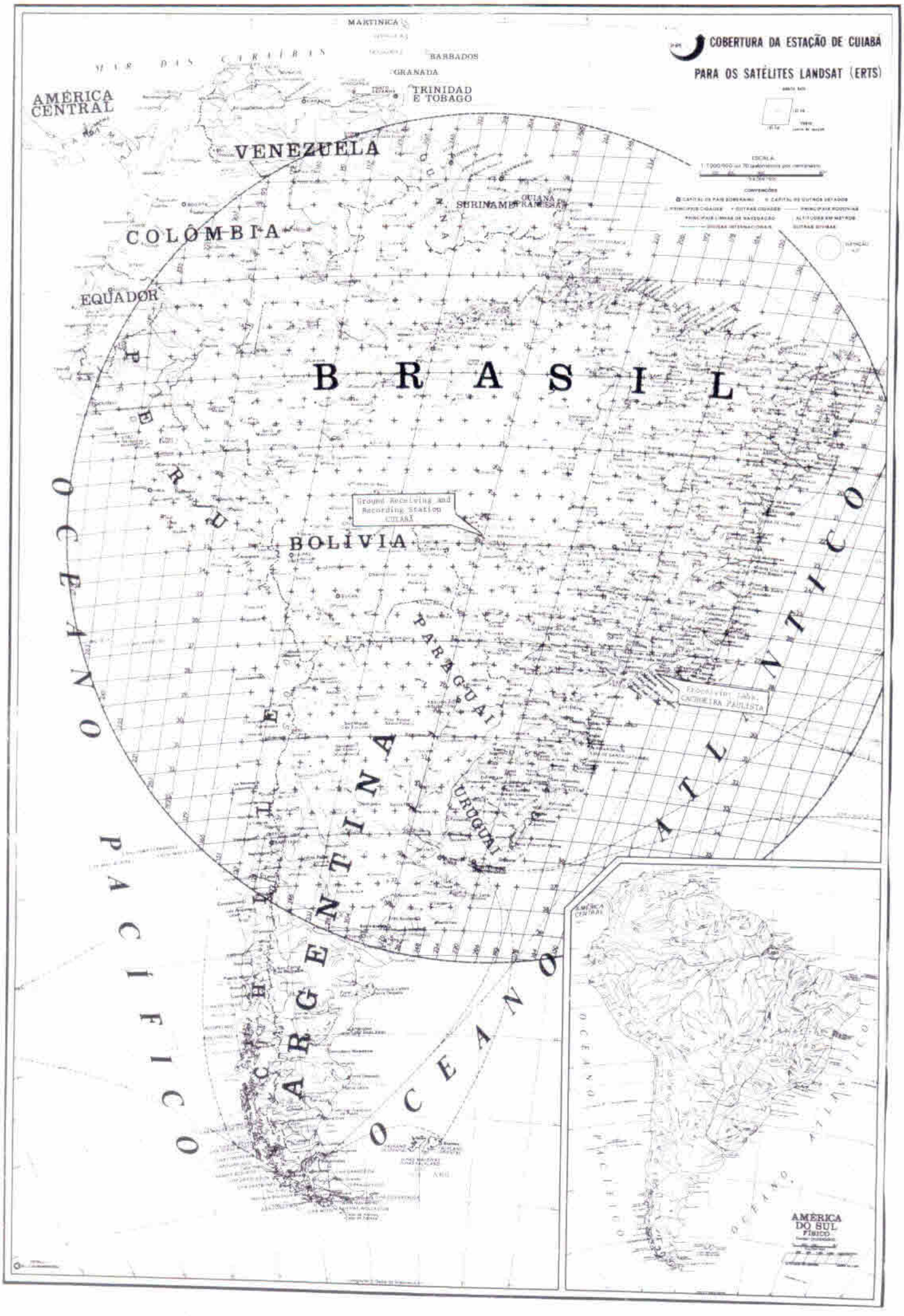

Fig. 5 - Cuiabá Receiving and Recording Station - Coverage Area

of the antenna in azimuth. An option which eliminates that problem is an X-Y type antenna, currently used by NASA in its tracking and command stations, instead of the traditional Az-El.

It is imperative that the recording sub-system has provisions for an accurate check of the quality of the recorded signals, which will prevent the recording of unrecoverably noise data (see item 2.1.5).

It is also important to have a reliable time base for the Station, which may be used as a reference for taking the Time Bias out of the satellite clock. Such datum is important in order that we can, afterwards, refer to the orbital data (expressed in UCT) at the satellite time, which is transmitted together with the video and telemetry information.

This is also the time to think of compatibility with other reception and processing centers, through the adequate choice of a station tape. The NASA recommendation is to standardize the recording

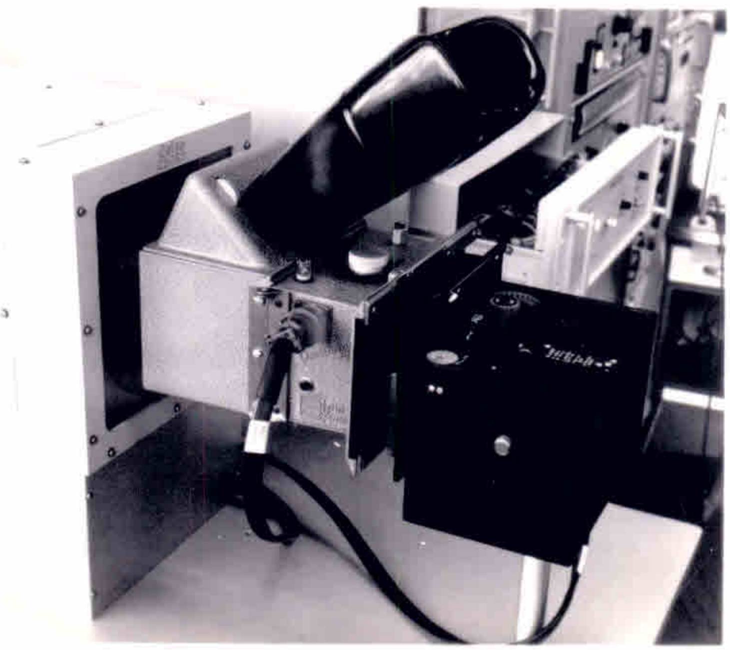

Fig. 6 - Quick-Look Image Recorder

as serial-in-serial out in the output of the signal receivers, for this choice would involve a minimum cost to the systems already existing. It would be quite convenient for a system still being planned, to specify the recording and processing parts already compatible with an inter-station standard, in the event of we don't desire redundancy or the budget doesn't allow for two types of recorders.

As to the sub-system of electronic processing, here are some recommendations:

First, relative to the sub-system output: if the Receiving and Recording Station acquires, on the average, two daily passes, the electronic processing sub-system must have the capacity of generating, at least , 4 (four) passes of the same size (the same average number of scenes) a day, in film, that is to say, twice the number that is recorded. The following reasons support the above:

- Possible existence of a back-log of recorded orbits, if the recording sub-system gets into operation before the processing one; this may occur by decision of higher authority;

- Need for the regeneration of films for the Photographic Laboratory in the future, due to problems of scratches, humidity, possible other damages to the originals, etc.;

- Down-times in the Electronic Processing Laboratory much more frequent than in the Receiving and Recording Station, causing accumulation of recorded orbits.

As to the CCT production, the speed and recording density of the tape units represent, together with the computer memory capacity, the greatest limitations to the production potential. If the magnetic tape units of our computers had a greater recording density (for example, 1600 bpi and speed), our CCT production capacity would certainly be much greater.

In the event of an option for a color Moving Window Display in the system, we have to remark that, in our case, the MWD proved to be of a much greater usefulness than initially anticipated. Besides being useful for the choice of areas for CCT, or as a demonstration equipment, the MWD has been an instrument for the estimation of cloud coverage, before the actual processing for the film, during the periods in which the QLM of the Receiving and Recording Station was inoperative; an instrument of quality control of the CCT's generated; a powerful debugging instrument of the system (because the video data follow the same path as the film recording, from the MSS recorder up to the computer memory), and also a powerful graphic instrument (once it has this capability) in the programs of support to the production.

Fig. 7 - Electronic Processing Laboratory - General View

Another recommendation refers to the computer capacity. It is always interesting that the electronic processing computer or computers have free time to be utilized in support activities. This, evidently, in the event of lack of funds to buy an auxiliary computer for general support of the system. For example, our computer system of the Electronic Laboratory even this day is still being utilized for support activities, such as: control of the tape file; control of the product deliveries, users, generation of geometric correction tapes, etc., besides the developing of new programs, correction and optimization of the old ones. As we have neither speed nor memory enough for multiprogramming, the production activities have to be suspended during the execution of these others, which go so far as to represent half the time potentially available for production.

Only some time ago we managed to obtain another computer (not yet installed) for general control, which will handle all the activities already mentioned and such others as Data Bank, administrative support, support to the Photographic Laboratory and to the Receiving and Recording Station. We believe that independent computers for production and support are the best option (compatibility of the data media is essential and of the hardware is advisable), so that the support activities do not suffer during maintenance in the production system, and vice-versa.

In the interface between the Electronic Laboratory and the Photographic Laboratory, a decision of the highest importance is the polarity of the 1st generation imagery. In our case, we opted for the positive 1st generation, for the following factors:

- The greater informative tenor on the Brazilian ground truth is in the lower half of the radiance range sensed by the satellite. With positive 1st generation, this band occurs in the best response region of the film (medium and high densities);

- The positive 1st generation allows negative 2nd generation (work copy) and the delivery of positive 3rd generation to users, by utilizing only conventional films and papers, which is economically interesting. The use of reversal films is limited to the requests of negative 3rd generation in 70 mm (contact copy).

With relation to the choice of the equipments for the Photographic Laboratory, we suggest first a survey of the potential users in an attempt to estimate the quantity of products to be supplied. In a first order of magnitude, by observing our regular distribution of data in these last 2 years, an average of 100 (one hundred) photographs per year, by user, was estimated. We also observed that about 40% of them are 70 mm negative (showing a particular tendency of the users to have their own photo files), and the rest, by a great majority, are paper copies, 40% in 1:1.000.000 and 20% in larger scales (1:500.000 and 1:250.000). Unfortunately, our data only covers the production line of black and white, since that of color products was started only very recently.

For a high production allied to quality of photographic reproduction, automatic processing machines, cheaper if they receive films or paper in rolls up to 11" wide, will be required, besides sophisticated enlargers. In our case, we possess automatic lines for products up to 11" wide, black and white, and color, manual processing being used for the larger sizes. We must emphasize that there are machines that, if adapted, process films reversal or not, as well as others which process only a given kind of paper. So, much care must be taken in these choices.

Another important characteristic to be observed in the machines, for example, is whether or not a leader and/or a trailer are needed for the film processing. This need raises the price of the process and decreases the production potential. On the other hand, a desirable characteristic is the step-repeat capability of the contact printers, which will avoid our having to copy tens of scenes, when we desire only one or two, and still worse, when we desire more than one copy of the same scene. It is obvious that, in this case, there should be a way of locating the desired scene in the roll of the original film. Therefore, the scene and band numbers must be coded in the film, so that photo--sensitive devices may decode them and present the information to the operator. This codification will be mentioned later on, when we speak about the color composer machine. We point out, besides, the need of specular light for the contact printer, when copying emulsion against emulsion is not feasible.

The throuput of these processing machines (Figure 8) will cause, if the number of requests is small, a lot of idle time which may be decreased through contracts for other photographic service (if possible in-house), or through the support to some program of aerophotogrametric surveying, preferably connected with the LANDSAT program.

Fig. 8 - Photographic Processing Laboratory - Automated Sector

Sometimes, the machines of a certain line possess distinct production capacities and, therefore, the actual capacity installed corresponds to the smallest capacity existing in the line. The bottle-neck of the line will be this machine. It is, thus, advisable to have all machines of similar capacity.

We also recommend having in duplicate the automatic processing machines for the processing of the film generated in the Electronic Laboratory, chiefly as a guarantee of the continuous processing of the 1st products. These machines, as well as equipments for quality control (light tables, sensitometers, transmission and reflection densitometers - Figure 9) should be operating even before the installation of the Electronic Laboratory, for support during its acceptance tests.

Fig. 9 - Photographic Quality Control

2.1.3 - PERSONNEL TRAINING

The personnel training is fundamental for the future stability of the system and it should take place even before the installation phase.

In the Brazilian case, a group of electronic engineers was sent to the exterior soon after the choice of the recording/receiving and electronic procession sub-systems, for training at the suppliers' installations.

The training period for the recording/receiving personnel was about 4 months and 3 engineers participated in the program (1 in the telemetry area, 1 in the recording area, 1 in the coordenating-system area), although 5 would be the ideal number as a precaution regarding the future stability of the group.

For the electronic processing personnel, the average of the training was 7 months, and 5 electronic engineers were sent (1 in the computer hardware area, 1 in the software area, 1 for the MSS signals processing, 1 for RBV and 1 in the coordinating-system area). For the reasons mentioned above, perhaps the ideal number should have been 7 or 8.

We must observe that it is extremely desirable that the appropriate elements of the working group participate in the training group, provided that their posterior involvement with the operation of the system is assured.

Besides the training in the suppliers factory (Scientific Atlanta and Bendix Aerospace System Division) there were visits to NASA (Goddard Space Flight Center) and to CCRS (Canada Center for Remote Sensing), which, at that time, already possessed systems in operation.

Later two other persons were sent to exterior, for two months, to the photographic processing and data bank. Four would have been the ideal number. Besides training at NASA and CCRS, these people also visited Eastman Kodak Company - Rochester, and EROS Data Center Sioux Fall, which was being installed at that time.

The experience acquired with these activities gave to our personnel a better technical background, which proved its value chiefly during the acceptance tests. It was also important as a basis for the future technical autonomy, that today is already being felt in several areas.

It would have been very profitable if these groups had visited systems in operation even before the choice of the system to be purchased, with the objective of taking advantages of the best particularities of each one. This was not possible at the time, due to internal constraints, but today this is our recommendation. Long training periods at the suppliers' will also be important, as well as the training that certainly must occur during the installation, now for a greater number of people.

2.1.4 - BUILDING DETAILS IN THE RECEIVING AND RECORDING STATION

Considering that the installation of the Receiving and Recording Station may be in a site remote from the Processing Laboratories, as is the case in Brazil, and besides the importance of the balanced operation of this sub-system, some building details must not be forgotten in the Station. They are:

- Concrete base for installation of quick-look recorder;
- Place and installations for the processing of quick-look films (minimum - 20 m^2 darkroom, with hot and cold water);
- Library, for filing and consultation of technical documentation and publications;

- Room for storage of magnetic tapes and films (temperature 21°C, 50% relative humidity);

- Room for storing spare parts and test equipments, as well as workbenches for maintenance technicians;

- Full view of the antenna from the telemetry room;

- For a system similar to ours, the telemetry room should have a minimum area of 60 m^2;

- Telemetry room should have a raised "false floor", good conditions of cleanness (an air shower is advisable), and controlled temperature and humidity (the same as mentioned above). An area for expansion for the future receiving of data from other satellites should be foreseen;

- Power generator and voltage regulator for use during satellite passes if the main electrical supply is of low reliability;

- Lightning arrester, earth mesh and transient supressors;

- Fire prevention system;

- Telex for receiving the NASA information on the passes and for communication with the Processing Laboratories.

By analysing with greater detail some of the above items, we will justify them. A site for the quick-look film processing is important not only for the recorder calibrations (focus, alignments, etc.), but also for the future establishment of a small distribution center of these data, if such be the case.

An organized technical library will help the maintenance personnel with the fast delimitation of the problem spots, as well as allow a permanent technical up-dating of the whole personnel, provided, evidently, that the library is supplied with good periodicals and handbooks.

Fig. 10 - Cuiabá Receiving and Recording Station - Antenna

Due to the distance, there is the need of having in stock, in the Station, a large quantity of spare parts, as well as test equipments; thence the suggestion for store-rooms.

The good conditions of cleanness, temperature and humidity in the telemetry room will help in the perfect functioning of the equipments. In dusty and warm regions, the control of these variables must be rigorous.

In order to guarantee the perfect recording of the signals during the whole pass of the satellite, the use of a power generator and voltage stabilizer is advisable, if the local system is of low reliability.

Lightning-arrester and earth mesh besides transient supressors in the equipments are quite important to avoid damages caused by electrical discharges. Frequent regular checks on this protection system must be part of the Station test routines.

The existence of a large quantity of expensive, hard to replace, electronic equipments besides the magnetic tapes and films, justifies the installation of an effective fire prevention system.

2.1.5 - INSTALLATION AND TESTS OF THE RECEIVING AND RECORDING SUB-SYSTEM

The installation of the Receiving and Recording equipments is less complex than that of the processing sub-system, due to the far smaller number of units involved as well as for the simpler technology. Besides, there isn't a central equipment to which all the cabling converges. Therefore, the chances of crowding of cables and interfaces is smaller. The lay-out, in this case, follows a disposition in series, that is to say, a natural sequence from the receivers and antenna controls to the recorders.

We only point out to the necessity of allowing space around the equipments, for easier maintenance and for the furniture (tables, shelves, chairs) necessary for office work and documentation handling.

After the installation of the system, there are some procedures and checks which must not be dispensed with for the equipment tests, as below.

The adjustment of the antenna collimation is essential to decrease the possibility of signals acquisition through the side lobes. Besides, we must verify the adjustments of rotational speed, mainly in Az-El antennas, for passes close to the zenith.

A signal generator, capable of simulating the satellite signals, must also be utilized for the calibration of tracking and receiving equipments, under controlled conditions.

As operational requirements for the acceptance, we recommend that the suppliers should deliver a check list covering action items before and after the passes and a program for pre-calculation of the antenna pointing data. As a verification of its efficiency, the check list must be utilized in actual passes of the satellite, and the program can be run in the Electronic Laboratory or in other available Processing Center. It must be noted that the input data for a program of this sort (equator crossings and orbital elements) need be provided periodically by NASA.

Considering that the beginning of the operation of the Receiving and Recording Station probably will happen before the total installation of the Processing Laboratory, we suggest:

- The utilization of a digital-analog converter and corresponding display of the MSS data received, after the demultiplexer and also in the reproduction outputs of the recorder. This will allow the verification, in a more accurate level, of the quality of the video received and especially of the recording quality, avoiding future problems with the data processing, due to incorrect calibration of the equipments;

- The recording of actual signals of several passes and the later shipping of these data to any Processing Laboratory, already in operation, capable of analysing in a detailed level the possible problems still existing. The Receiving and Recording Station may not be considered operational before such a verification. The production of quick-look images must not be accepted as enough for this aim, having in view that not all of the future Processing Laboratory functions are exercised in this process. The quick-look imagery may not indicate all the potential problems possibly present in the video data stream. Evidently, the Station and the Laboratory which is going to be utilized for the recommended check should be compatible, according to what was mentioned in item 2.1.2.

2.1.6 - BUILDING DETAILS OF THE PHOTOGRAPHIC AND ELECTRONIC PROCESSING LABORATORIES

In the same way as important details were overlooked in the analysis of the proposals for the choice of the respective sub--system, the lack of industrial experience, in our case, brought about considerable delays in the building of the Processing Laboratories.

First, we will provide some general recommendations and, soon after, some specific ones for each laboratory. It must be considered that both laboratories are located in the same building, for convenience of fast processing and communication, in the town of Cachoeira Paulista, 1,900 km away from the Recording and Receiving Station, in Cuiabá.

The localization of the building, itself, must take into consideration the existence of resources necessary to the good functioning of the laboratories, such as reliable electriacl supply network (in this case, a generator for the whole building would have to possess an enormous capacity),water in sufficient quantity and quality, transport and communication facilities and availability of rapid technical assistance by the contractors.

The determination of the area to be utilized by the two laboratories must be careful and must allow, from the beginning, for future enlargement of the system. Evidently, depending on the capacity of the photographic and electronic sub-systems, different areas will be occupied. In our case, the laboratories occupy 1,700 m^2 area, with no allowance for expansion.

The special installations (pipes and ducts for hot water, cold water, compressed air, air conditioning and exhaust gases, electrical and communication network - Figure 11) must be installed aiming at an easier maintenance and possible modifications. For this, there are two kinds of solutions, that are not mutually exclusive. One is the use of apparent installations, generally fixed to the ceiling. The other is the utilization of a basement, avoiding problems and dirt during any repair or modification of a given line. This basement may also house and protect the equipments of these special installations (compressors, conditioners, pressurizers, heaters, etc.) avoiding the construction of separate engine and equipment house.

Lightning-arrester and earth mesh, besides the transient supressors in the equipments, are quite important, as we have already seen in item 2.1.4. Here we emphasize the convenience in installing two independent meshes: one for the building and utility power and the other for the electronic equipments.

As to the fire prevention system, for this case, additional care must be taken, in comparison with the one at the Receiving and Recording Station, due to the great quantity of inflammable material in the Photographic Laboratory.

Fig. 11 - Processing Laboratories, Special Installations

Practically, all of the work areas in the building will need controlled temperature and humidity, according to the requirements of the equipment and material manufacturers. Some require tighter conditions, such as the processing rooms and the film file rooms; others only require conditioning for the comfort of personnel.

The care with clean conditions, in the room of Electronic Processing Laboratory and in the whole Photographic Laboratory, is fundamental for a good performance of the machines, allied to a low rejection rate in the products. As a suggestion, separating the controlled areas, there must be clean-up cabins ("air shower" type) and appropriate shoes and clothes cleaners (chiefly in the Photographic Laboratory).

The installation of a telex terminal for communications with the Receiving and Recording Station and others as necessary is highly desirable, as already seen in item 2.1.4.

2.1.6.1 - DETAILS IN THE ELECTRONIC LABORATORY

In the Electronic Laboratory, besides the items already mentioned, it is convenient to foresee:

- Processing room with raised false floor and dimensions such as to permit future expansion. In our case, an area of about 170 m^2 proved to be satisfactory. Nevertheless, if the processing room is utilized for other functions, in addition to production, chiefly when it is intended to have a computer system of medium or large capacity, which will give support to other sectors of the agency, the room dimensions will have to be increased;

- Store room for storage of video magnetic tapes not yet processed and other magnetic media which the system may come to utilize;

- Warehouse of spare parts and consumables;

- Room for filing and consultation of documents relative to the equipments and technical publications;

- Room for maintenance, including workbenches and test equipment, with an easy access to both the processing room and to the warehouse;

- Direct communication between the processing room and the Photographic Laboratory, for the delivery of exposed films and for the receiving of virgin films;

- Concrete foundations for the film recorder(s) in the processing room;

- Outlets of dry compressed air, for the cleaning of the magnetic heads and other equipments;

- Voltage regulator for the equipments of the processing room (this kind of equipment uses to be more sensitive to voltage variations than the commom electronic equipments);

- Some kind of electromagnetic shielding for the Electron Beam Recorder(s), if such machines are used.

2.1.6.2 - DETAILS IN THE PHOTOGRAPHIC LABORATORY

Besides the mentioned ones, the following details should be observed:

- Separation of darkrooms from areas of normal work through rotating cylinders, for insurance against unwanted light and for space economy (see Figure 11);

- Mixing room and feeding of the automatic processing machines on a floor above the Laboratory (Figure 12), avoiding the utilization of pumps; the machines will be fed by gravity;

Fig. 12 - Processing Laboratories Building (Mixing room appears in the 2nd floor)

- Cold chamber for long term storage of films (about a year), with two independent compartments and different temperatures, to allow declimatizations;

- Room for storage of chemicals after mixing;

- Room for storage of spare parts and test equipments, as well as workbenches for maintenance technicians, with an easy access to the processing areas;

- Room for filing and consultation of the documents relative to the equipments and technical publications;

- Room for filing of the work films (2nd generation);
- Communication system with all the darkrooms, for safety purposes;
- Door for eventual passage of machines and large quantities of consumables, such as chemicals, films, papers, packages. It will be useful also as an emergency exit;
- Lines for water supply to the processing machines equipped with flux reduction valves. Without these valves (of the flow-meter type) our laboratory used to consume up to 200,000 litres of water a day, which dropped to about a half after their installation;
- Battery-operated safety lights, against power outages;
- Power generator of the no-break type for the machines processing 1st generation satellite and air-survey films if electrical supply system is unreliable.

2.1.7 - INSTALLATION AND TESTING OF THE ELECTRONIC PROCESSING SUB-SYSTEM

2.1.7.1 - EQUIPMENT INSTALLATION

In the equipment installation there are several aspects which must be taken into consideration in order to obtain a greater operationality and reliability.

The utility of a raised false floor is quite evident, taking in account that the volume of the cabling among the equipments, in a system of this kind, uses to be considerable. A flexible lay-out is extremely desirable.

We observe that in the physical location of the equipments it is better to count on excess space than to strive for space optimization (of course this must have already been taken care of when dimensioning the processing room). We must remember that the system is subject to changes and expansions. Besides, when some machine is in maintenance, it would be undesirable that the circulation be bottled up by people and test equipment around it and, yet worse, that the maintenance personnel lacked enough space for working with liberty.

At last, we must not forget the need for furniture, such as desks for filling out of forms and operation control, files and cabinets for administrative purposes and/or maintenenance, in the processing room.

After this, a final comment on the lay-out is to remark on the convenience of having visual control of most or all of the equipments from the control position (normally the console terminal of the computer).

The same recommendation of having space excess rather than optimization applies, with double importance, on the internal disposition of the equipments within the cabinets and racks. This is particularly applicable to the computer system, where most of the cabling and interface devices converge to. Over populated racks and cable bunching (Figure 13) may, effectively, cause serious problems of interference and cross-talk, which may degrade and cause the most different kinds of processing failures, with the aggravating fact of being extremely difficult to locate and correct. We must add to this the obvious difficulty of maintenance in a rack in such conditions, besides the problems with adequate ventilation of cabinets.

As to ventilation, a parenthesis must be opened on the subject of air conditioning. A false floor system having been utilized, a natural solution would be to blow the air from below the equipments. This, however, demands a much greater care with relation to cleanness. There is a tendency for dust concentration on the floor and this dust is thrown inside the equipments. Nowadays, many manufacturers deliver the equipments with the ventilation system oriented downwards.

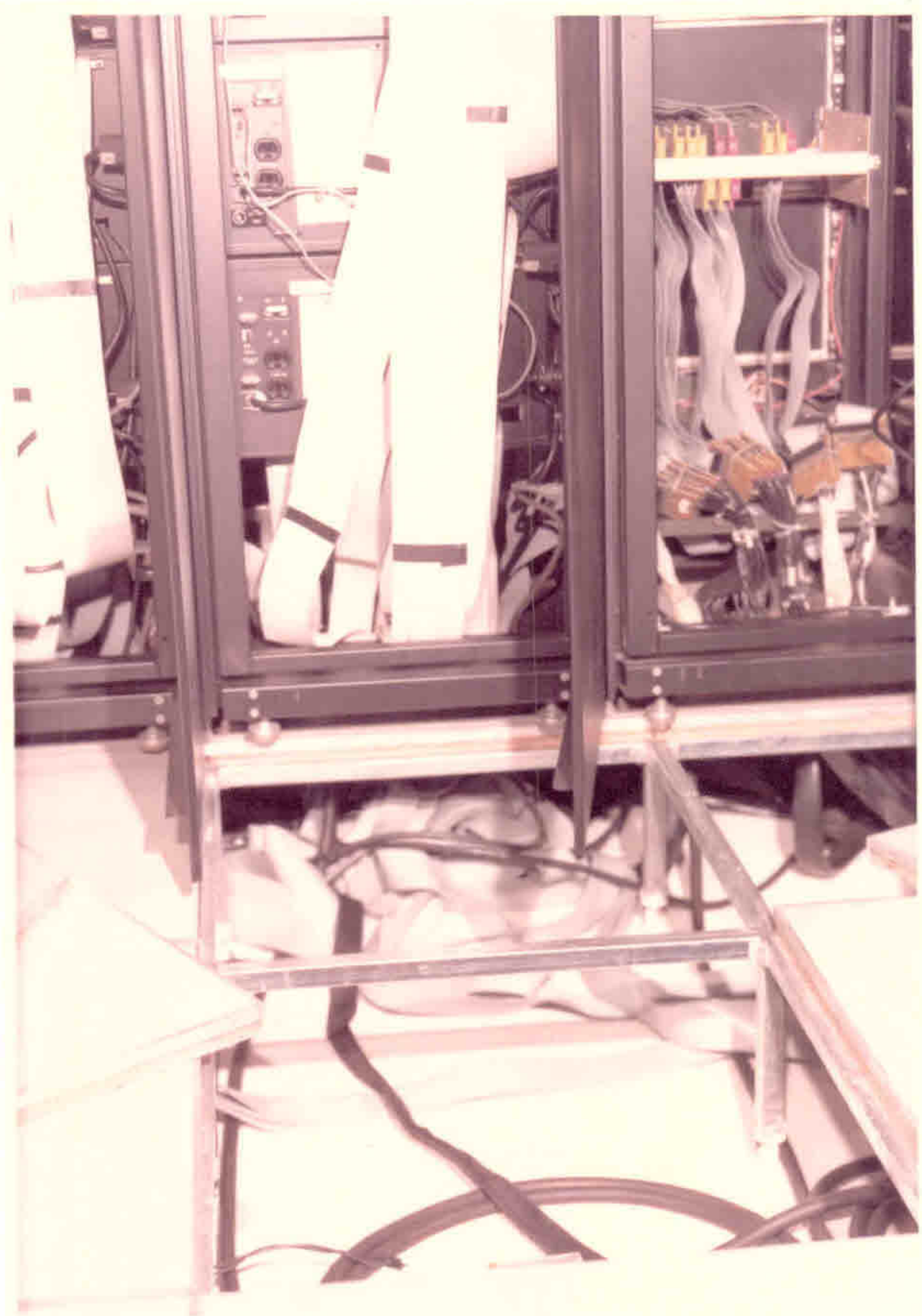

Fig. 13 - Electronic Processing Laboratory, Convergence of Cabling to the Computer System

Back to the installation, particular attention must be given to the strain-reliefs. With the number of wires involved, the cable weight and the pulling of racks for maintenance, the only way to avoid broken wires, loose connectors and even displacement of printed circuit boards from their slots, is a good system of clamping the cables to the equipments allowing, at the same time, the possibility of moving them adequately for maintenance and/or cleaning.

2.1.7.2 - TESTS OF THE INSTALLED EQUIPMENT

A mistake frequently made in acceptance tests is to concentrate on the performance specifications of the system, forgetting the operational aspects. Of course, those must be demanded but, starting from the premise that we are dealing with a production oriented system, there is a series of characteristics that range from desirable to essential in the system.

Unless we can count on a comprehensive data base in interaction with the production system, not usually the case in a system being installed, much of the information for the processing of an orbit must be manually entered by an operator. It is very important that the system should allow a reasonable flexibility in processing options but, at the same time, it is desirable that these options may be specified in a simple and concise way. As an example, our processing system, as delivered, made a total of 30 (thirty) questions to the operator before starting the production of an orbit in film. Currently the operator answers only 8 (eight) questions and, yet, some information are knowingly redundant (for example, orbit number, path number and pass date), for consistency checks. This is also essential to avoid, as much as possible, beginning a process with wrong parameters, which would cause, afterwards, the need of product rejection, there having been, therefore, waste of time and material. As simple as it may seem, the possibility of backing up after perceiving an error in a previous answer, is advisable. Having to abort a program and to call it again unnecessarily raises the price of the processing. Another desirable characteristic is to allow resuming a process, stopped for some reason, from the point of interrumption, thus avoiding the cost of beginning again from the start a process which was already midway. This possibility proved to be quite common in our system.

A primordial necessity which will appear in any production system is to control its own production. For this, it is essential that the system can document, automatically, the processing, issuing a hardcopy report during or after the production and also produce that documentation in a data medium readable by the support software, for later automated control and additional data input, such as cloud coverage and image quality.

Regarding the support software, it is highly desirable that the system supplier should deliver a program capable of generating the BFET (Best Fit Ephemeris Tape) tapes instead of depending on NASA for their sending, which may delay the delivery of the products to users.

If this is not possible, we recommend that, from the beginning, effort be devoted to produce the program. The input data will continue to be provided by NASA, but via Telex, which doesn't represent delay face to the average time for the production and arrival of a BFET from NASA (which is generated only after all the satellite passes it covers).

Concerning the performance, there are some points to be reminded as essential specifications:

- The geometric repeatability (which may be checked with double exposure, in case the recording is not by continuous film motion);
- The registration among bands, for production of color composition (the same procedure as above, or the generation of the color composition itself. The check should be made with real imagery, because there are problems of band offset which don't appear in test images);

- The geographic repeatability (verified by comparing the indications of geographic coordinates of two or more passes over the same path and also by verifying the coherence between adjacent paths);

- The radiometric repeatability (verified by controlling the density steps, of the gray scale, after having the photographic processing machines under rigorous control);

- The radiometric equalization (the system must have provisions for decreasing the banding effect caused by the different responses among the sensors of the same band - the so-called sensor mismatch);

- The cosmetic effects (the system must produce images which minimize the factors which may harm their aesthetic effect, because this may represent potential rejections of the product and consequent decrease in the system efficiency);

- The capacity of effective production (throughput) of the system (including support activities) must be good enough to satisfy the necessities, within the limitations of time and personnel which the organization faces. This characteristic must be tested with several real orbits recorded in the Receiving and Recording Station in order to reproduce, in the best possible way, the actual conditions of the operation.

Finally, we reiterate our suggestion about the acceptance of the Receiving and Recording Station, in the sense that the sub-system should not be accepted before a Photographic Laboratory, already in operation, processes and evaluates the product in film (1st generation). The same is applied to the eventual CCT's produced, which, naturally, would go to an Electronic Laboratory.

2.1.8 - INSTALLATION OF A PHOTOGRAPHIC PROCESSING SUB-SYSTEM

As already mentioned in item 2.1.2 we had no formal installation and acceptance tests of the equipments in each production line of the Photographic Laboratory, since they were being purchased as resources became available.

We had, in the beginning, the installation of the processing machines for the 1st generation B & W films, generated in the Electronic Laboratory, besides the equipments of quality control, both of them giving support to the acceptance test of that laboratory. Soon after, enlargers, printing machines and B & W paper processors arrived. In this way, the production line for B & W products was already assembled and were able to begin the distribution of INPE-generated products to users. Only after some time did we begin the production of color products.

The lack of precise knowledge on how to control the processing machines, as well as on how to choose and work with photographic material which might reproduce with quality the 1st generation film, resulted in that no more than regular quality products were distributed to users during some time, throwing doubts on the quality of the acquired data.

Today, with the experience acquired, we have some suggestions.

Firt, the Photographic Laboratory must concern itself with processing with fidelity the 1st product generated (in our case, B & W positive 70 mm, in the four channels). The equilibrium in the photographic processing of this film will provide precise feedback information to the Electronic Laboratory on its processing problems, such as density range, focus, spots, scratches, misalignments. The most important problem that we had was with density range, once that as the eletron bean and the anode aperture were utilized, changes in the gray scale were observed after the photographic processing, without, however, being related to this use (progressive clogging of the aperture). It was a typical problem of lack of processing machine control and various tests had to be made for determining the ideal number of racks, chemical concentration rates, machine speed, etc. For the control of the processing of this film, we recommend the running of test strips of the same film through the machine, at least just before and after the processing of each roll, in order to be sure of the machine conditions during the processing. These tests must be made before the sub-system goes into normal operation. The figure that follows (Figure 14) shows an example of a test strip and a processing control graph.

After being assured of the quality in the processing of the 1st generation film, the Photographic Laboratory must begin the tests with the work film, that is to say, the one that will really be utilized in the production. In our case, the 1st film is Kodak SO-219, produced in positive, including gray scale in 16 levels. The work copy (2nd generation) is a negative, also 70 mm, and the products for the users are 3rd generation ones.

The more stable the 1st generation film processing is, the easier the obtention of the work copy (2nd generation) will be. The processing of this copy will be flexible enough for correcting the first generation film variations, which may occur by a hardware or material limitations. This film, in our case, is processed in a machine of the same model as the one which processes the 1st generation films, the only difference being in the parameters (racks, speed, chemical concentration) having in view the different characteristics in relation to the 1st film. Test strips must also be used for the process control. The duplication of the 1st generation film, for obtaining the work copy, is made in a high speed contact-printer machine, and we need to be careful in the constant checking of the light intensity.

In the same way that the control of the 1st and 2nd generation processes exists, it should also exist for the processing of products to be delivered to the users, and numerous tests must be made until the determination of the final characteristics of the product. About color products, we will talk later.

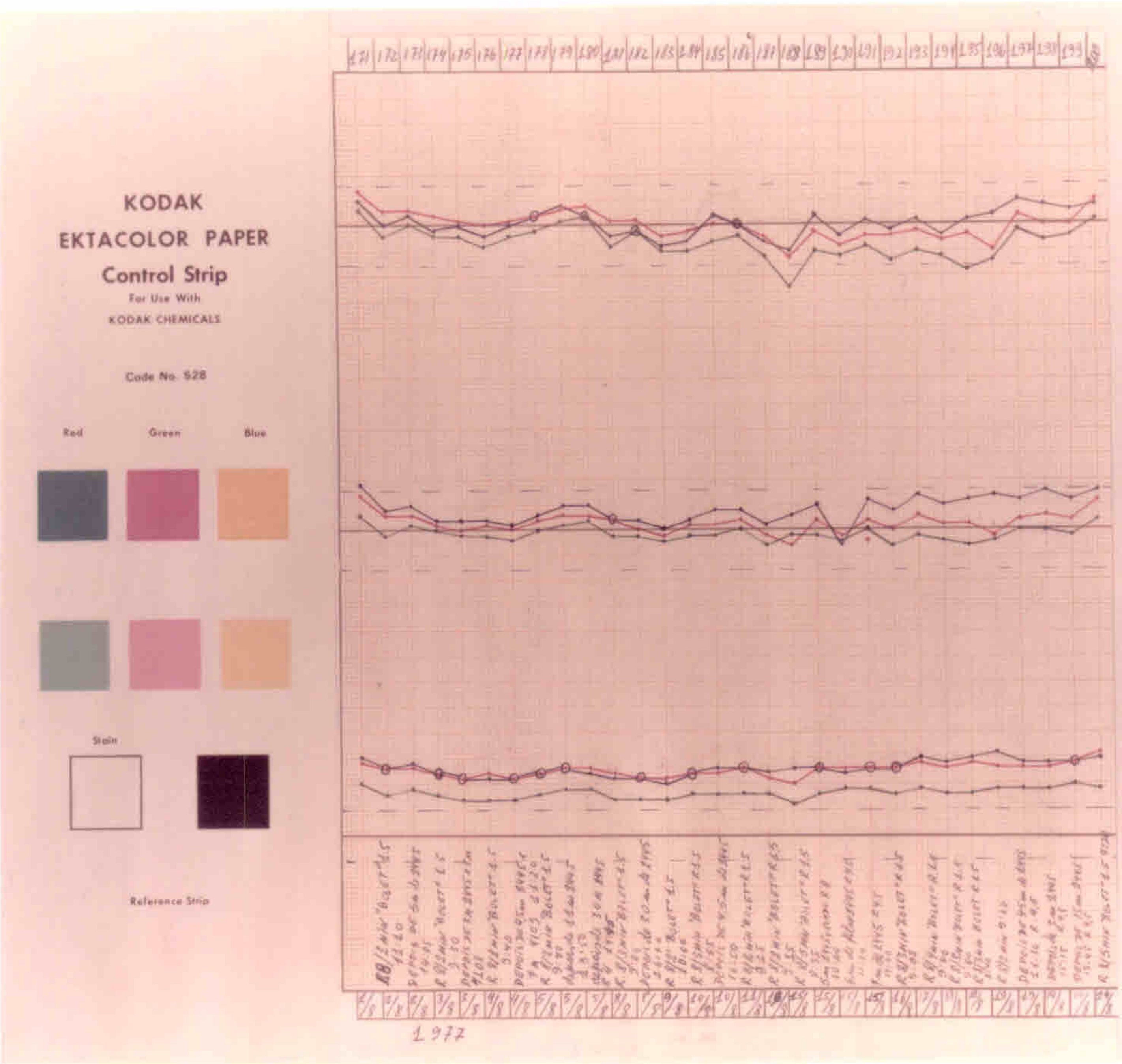

Fig. 14 - Photographic Control Strip and Machine Control Graph

From the beginning, the acceptance and rejection criteria for each product must be established, independly of the generation to which it belongs. This is the only way to guarantee the distribution of good quality products. For example, in the control of photographic quality, we must verify: minimum and maximum densities (for some products, also the intermediate step density) base, scale, focus, scratches, spots, registration, emulsion, Newton rings, granularity, etc.

A photographic system oriented to high production must consider the gray scale as a highly important factor. By its control in each product, we can quarantee the equilibrium in each line and the rejection rates will certainly decrease. By fixing and by controlling the range and limits of the gray scale in the 1st product, in the work copy, and in each type of product to be delivered to the user, a high production rate will certainly be reached.

The delay in the installation of the production line of color products caused serious problems for the Photographic Laboratory. As already mentioned, our 1st product is a positive 70 mm film, containing the different sensor channels. Similar to the Canadian system, our system has an automatic machine which composes, from the B & W film, a color negative in 9 1/2". In this machine the 1st generation film must be used as input (including a photographic code which allows photoelectronic decoding to present the reading, in a display, of the channel and frame being utilized - see Figure 15). Obviously, to obtain a high quality 9 1/2" color negative, the registration marks of the different channels must match when they are exposed one over the other, using different filters.

In the same way that we mentioned the need of using the gray scales to have a high production rate in B & W, the same is valid for color products. It is certainly true that not always a standard color product (scale perfectly gray and inside the previous established range) is the one that helps best the interpretation by the users. But,

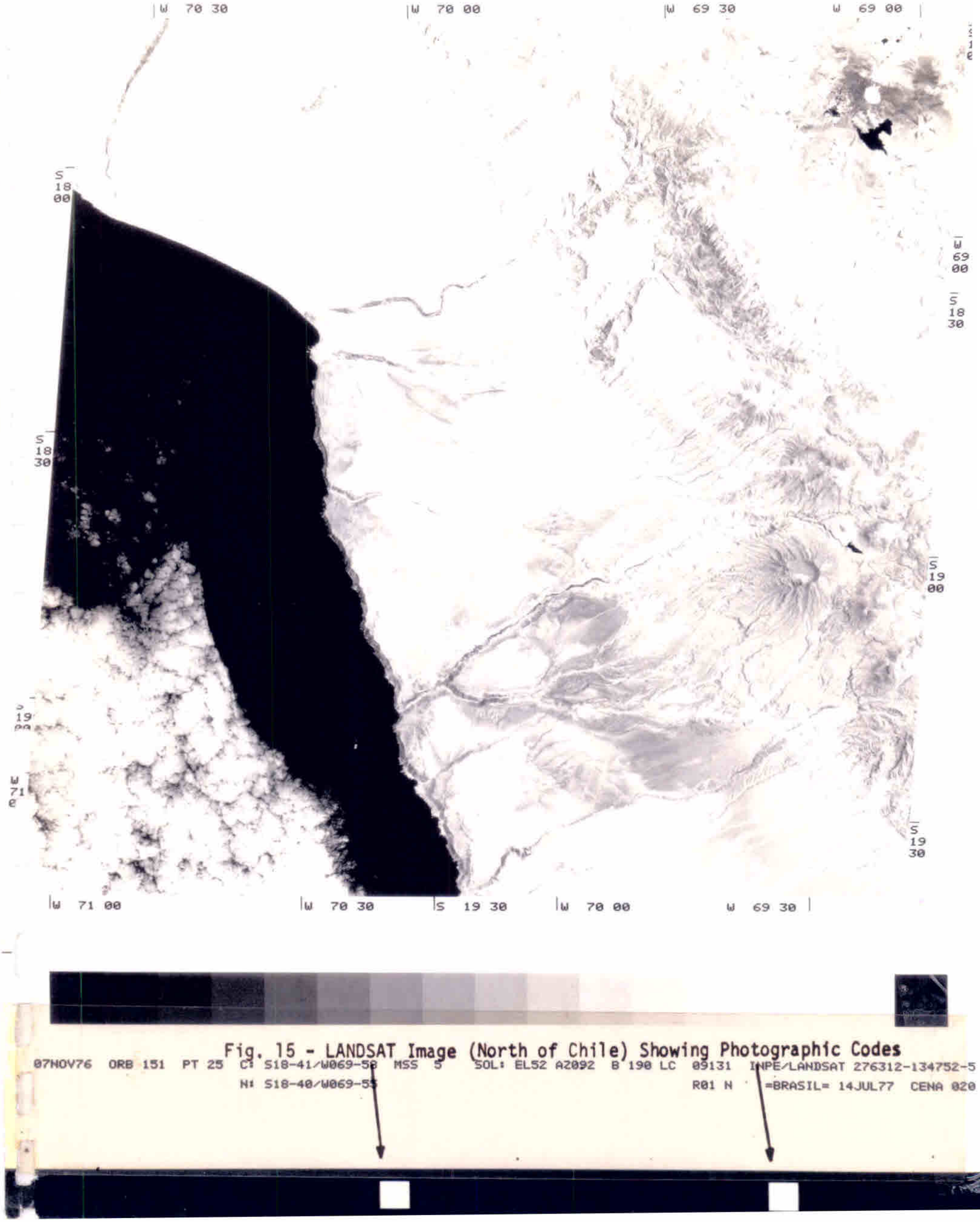

Fig. 15 - LANDSAT Image (North of Chile) Showing Photographic Codes

the production in line will demand control parameters for constant repeatability of the duplication process.

To have a perfect gray scale in the color product, we have to consider again the processing control of the 1st generation film, whose density differences among channels must not exceed 0.03, under risk of saturation of some color. The processing machines of both the color negative and the user products must also be controlled through control strips.

Concerning the quality control, we can say that its criteria are quite similar to the ones of the black and white line, with the only difference that now they take into consideration 3 (three) basic colors. Not only that, the 9 1/2" color negative must undergo the same inspection rigidity as the 1st generation film, once that it will be, for the color line, the 1st generation.

Finally, we would like to emphasize that a Photographic Laboratory should be considered operational only after the establishment of the following items:

- The films and papers to be utilized;
- The processing parameters of the automatic machines;
- The ranges and limits of density of the gray scales for each product;
- The acceptance and rejection criteria for each product.

The sending of its final products for an analysis in another Photographic Laboratory in operation is considered quite important for the beginning of an operational phase.

2.1.9 - DETAILS IN THE INSTALLATIONS OF DATA BANK / DISTRIBUTION CENTER

Due to internal financial problems, the building of the new Data Bank facilities was very delayed; it will also function as the Distribution Center of the program data. In spite of this, since the beginning we cared about the developing of the activities in this area, with the main objective of always increasing the number of users involved on the program.

Today, the Data Bank / Distribution Center functions provisorily in two sites: São José dos Campos and Cachoeira Paulista. In São José dos Campos, next to the Remote Sensing Department, which takes care of the researches, development and transfers of methodologies to the users, a small sector is situated; this sector handles the support to the users who go directly to that department for obtaining information about projects in development, system potentialities, correct placing of requests, etc. In Cachoeira Paulista (see Figure 16), in the same building of the Processing Laboratories, function the file areas, production of data catalogs, codification, follow-up of requests, user services, etc. Soon, the Data Bank / Distribution Center will operate in new facilities which will allow a greater ease to the users in the retrieval of the data necessary to their projects.

Some details of the new building are:

- Separate room for storing magnetic tapes and 1st generation films, for reasons of climatization and safety;

- Library specialized in Remote Sensing Subjects;

- Auditorium for training courses;

- Fire prevention system;

- Room for future installation of a computer for data storage and retrieval (initially, only a terminal connected to the system's general support computer, which will be installed in the Electronic Laboratory);

- Room for user services, including light tables, photomosaic tables, microfilm readers, displays, sample of products, data catalogs in general;
- Telex for receiving requests and communications.

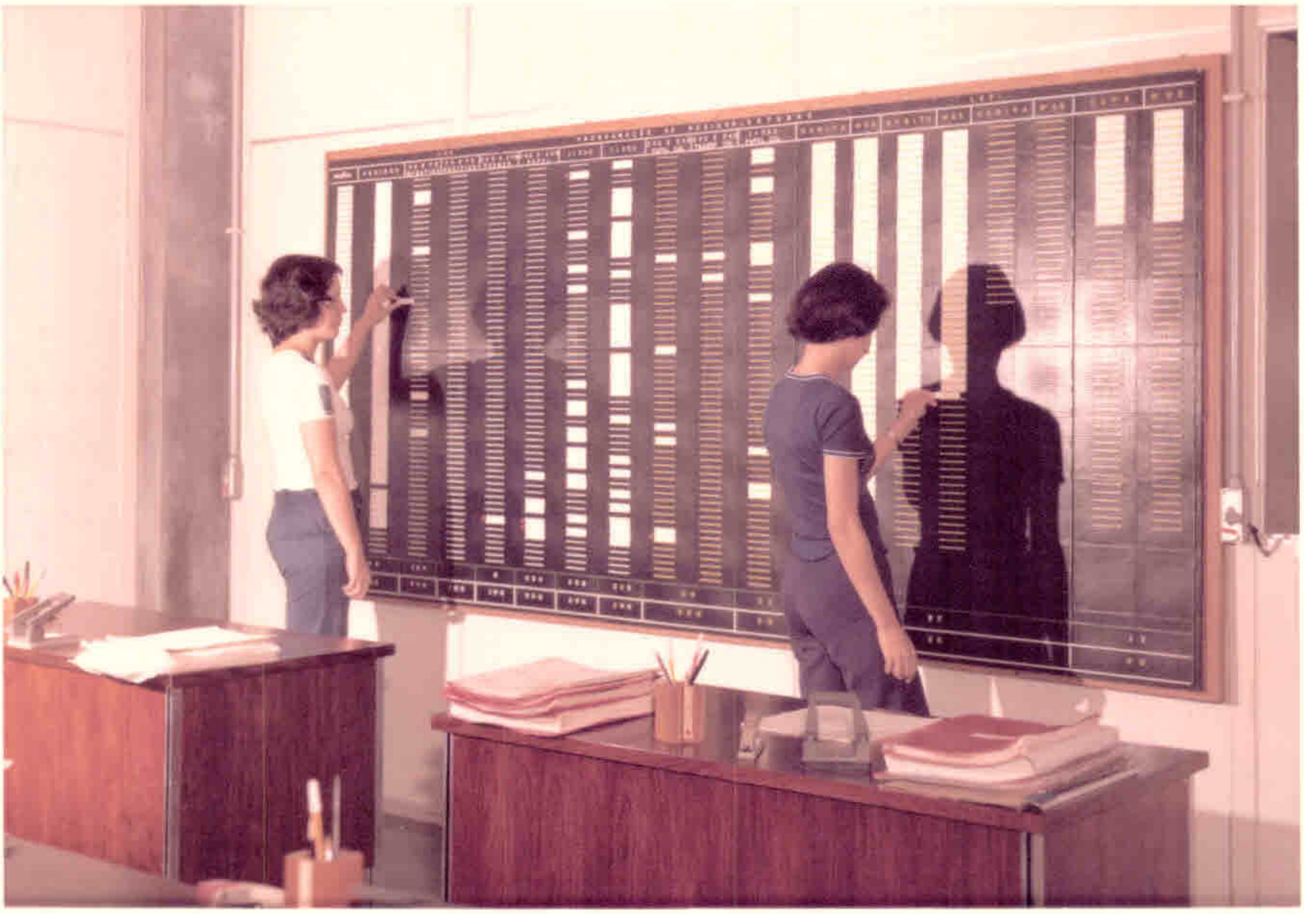

Fig. 16 - User Requests Follow-Up Display,at Cachoeira Paulista

3 - CONCLUSION

Throughout the document, we tried to expose several factors that would strongly help the success of the implantation and speed up reaching the operational phase. Summarizing the most important ones along with some perhaps not explicity mentioned:

- Emphasis on the operational aspects when specifying the production sub-systems;

- Exaustively assuring the recording quality at the receiving site;

- Emphasis on testing the sub-systems under real operating conditions, whenever possible;

- Existence of adequate logistics support (spare parts and consumables) for installing, testing and starting operations (failure rates are much higher in the beginning);

- Defining previously the structure, forms and operational procedures of a production data base capable of handling and allow control, from the beginning, of the fast-growing of LANDSAT related data;

- Establishing a moderate price policy to incentivate engaging of a reasonable number of users since the beginning;

- Promoting seminars and training to users in the several application areas with goal, among others, of the growth of product demand and subsequent more efficient utilization of the Processing Laboratories production potential;

- Maintaining constant contact with other LANDSAT Systems and with experienced users, whose feedback can provide the system with valuable information allowing improvements of final products, faster standardization and greater efficiency of operational procedures.

In the course of implanting the Brazilian LANDSAT System several administrative, financial and technical problems occurred. They caused serious delays in constructing the processing laboratories, on purchasing of photographic laboratory and on the building of the Data Bank / Distribution Center Facilities, not to mention the delays in phasing into an operational stage after installation. So, the presented chronogram should be understood just as information about our setting up, which, for the mentioned reasons, was rather lengthy.

Today, we believe that with available know-how, a similar system can be installed within about two years, provided simultaneous start up of the installation of all the sub-systems. The estimated periods would be:

- Receiving and Recording Station: 9 months;
- Electronic Processing Laboratory: 1 year and 6 months;
- Photographic Processing Laboratory: 2 years;
- Distribution Center: 1 year.

The above times can be eventually shortened with the advisory support from systems that have passed similar experience, which we, as the first developing country to install a LANDSAT system, did not have opportunity to profit from.