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THE INPE HANDOUTS TO THE 6TH LANDSAT TECHNICAL WORKING GROUP (LTWG) MEETING

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12. Revised by

Márcio Nogueira Barbosa

9. Authorship *José Luiz de Barros Aguirre*
Leopoldo Edgardo Messenger Parada
Sergio de Paula Pereira

Responsible author

13. Authorized by

Nelson de Jesus Parada
Director General

14. Abstract/Notes

This document presents the INPE handout material to the LTWG meeting held at its facilities in São José dos Campos, SP, Brazil, from 12 to 15 June, 1984.

15. Remarks

THE INPE HANDOUTS TO THE 6TH LANDSAT TECHNICAL WORKING GROUP (LTWG) MEETING

The objective of this report is to present the material that INPE will make available to participants attending the 6th LTWG meeting, to be held in São José dos Campos from 12 to 15 June, 1984.

Annex A presents INPE's LANDSAT Receiving and Processing System in its present configuration and status (Item 5B of the meeting agenda), as well as the experience already obtained with LANDSATs 4 and 5 (Item 10).

Annex B includes the revised tables of Station Plans for TM Reception and Products and of Implementation Schedule for Data Formats Employing Superstructure Conventions, for update of the LTWG documentation and presentation under Items 9 and 12 of the agenda.

Annex C is a short proposal for standardization of the Worldwide Reference Systems, which we felt could fit within the "new business" framework of the meeting.

Annex D shows INPE's preliminary TM Products Price List. There are open questions concerning exactly how the NOAA distribution fee would apply to some of the products.

Annex E contains a TM image received and processed by INPE, to illustrate the appearance of the products to be offered. Distribution to users is expected to begin later this month, depending on the solution of the questions concerning the NOAA fee.

ANNEX A - INPE's Landsat Receiving and Processing System

1. Configuration and Status

INPE's Landsat system is split into two sites. The Receiving Station is located in Cuiaba, Mato Grosso, due to its geographic position which favors the best coverage of Brazil and South America; the Processing Station is in Cachoeira Paulista, Sao Paulo, closer to the resources offered by the Rio-Sao Paulo region. The tapes recorded at Cuiaba are sent to Cachoeira Paulista by plane.

1.1 - Receiving Station

The present configuration at Cuiaba can be divided into four different functional subsystems:

- Tracking and receiving subsystem, including
  - one 9-meter parabolic antenna for S-band, with associated tracking and receiving equipment (Scientific Atlanta), installed in 1973;
  - one 10-meter parabolic antenna in cassegrain configuration for simultaneous S and X-band reception, with associated tracking and receiving equipment (Scientific Atlanta), installed in September, 1982.
- Recording subsystem, including
  - one paralell 28-track wideband recorder (Ampex FR-1928) for MSS, installed in 1973. Up to 2 satellite passes are recorded onto one 7200' tape.
  - one serial-in-serial-out 28-track high density digital recorder (Martin-Marietta) for TM or MSS, installed in February, 1983. Up to 2 TM passes or 6 MSS passes are recorded onto one 9200' tape.
  - one analog 4-track instrumentation recorder (Hewlett-Packard) for telemetry data, installed in 1973. Up to 2 passes (8 Kbps) or 5 passes (1 Kbps) are recorded onto one 2400 x .25" tape.
  - one serial-in-serial-out 14-track high density digital recorder (Martin-Marietta) for MSS, installed by NASA to support the Backup Plan.

  The old RBV recorder (RCA TR-70) was transferred to the Processing Station, as a backup to the existing one.

- Data monitoring subsystem, including
  - an INPE-built hardware allowing simultaneous display of the six MSS sensors from any band in analog form onto an oscilloscope CRT;
  - a COMTAL black-and-white visualization system with a 512x512 screen allowing real-time or playback monitoring of TM video data in a moving-window fashion.
- Computer subsystem, based on a DEC PDP-11/34 minicomputer and peripherals, performing:
  - generation of antenna pointing data printouts for satellite initial acquisition or manual reacquisition;
  - real time support of the antenna tracking as a secondary mode, in case of autotrack loss or malfunction;
  - downline loading of the COMTAL application software.

The Receiving Station is operational for both MSS and TM and both S- and X-bands, and has been recording MSS data from Landsats 4 and 5 over full acquisition range since launch. TM data are being received and recorded regularly since April 6, 1984.

1.2 - Processing Station

The present configuration at Cachoeira Paulista is best described if grouped by the instrument(s) to be processed:

- The old MSS/RBV processing subsystem integrated and installed by Bendix Aerospace in 1974, built around two DEC PDP-11/15 minicomputers and peripherals, including
  - one paralell 28-track wideband recorder (Ampex FR-1928) for the playback of MSS data, and its special interface equipment (Bendix Aerospace) capable of extracting from the incoming stream and routing to the minicomputers through separate lines the video, auxiliary data such as Time and Line Length codes, and synchronization signals.
  - one 70mm film Electron Beam Recorder (CBS) and special interface equipment (Bendix Aerospace) including D/A converters and geometric corrections circuitry to allow the computers to geometrically correct the images without the need for resampling.
  - one analog 4-track instrumentation recorder (Hewlett-Packard) for playing back telemetry data.

- one modified VT recorder (RCA TR-70) for RBV playback, and its special interface (Synaptic Systems) to DC-restore the video and route it directly to the analog circuitry of the Electron Beam Recorder, at the same time sending sync pulses to the minicomputers to allow synchronization with the geometric and radiometric (de-shading) corrections.

- one RAMTEK visualization equipment with a 256x640 color monitor allowing display of MSS video from either the wideband recorder (through the computer) or CCTS.

- one digitizer table (Bendix) for measuring X-Y coordinates to support either systematic calibration of the EBR with grid patterns or the generation of precision products based on Ground Control Points identified on bulk imagery.

- one Quick-Look equipment (Celco), connected directly to the MSS recorder, allowing the production of low-resolution, uncorrected imagery without computer interference, via a camera coupled to a CRT.

This subsystem is operational but the mean time between failures is decreasing due to age. It is receiving the addition of two new magnetic tape units (one of them already installed) to support CCT production with increased reliability.

- The new TM processing subsystem, integrated and installed by Societe Europeenne de Propulsion (SEP) in December, 1983, with the final acceptance tests concluded in February, 1984. This subsystem is built around a DEC VAX-11/780 and peripherals, and includes:

  - one serial-in-serial-out HDDR (Martin Marietta) for playback of the TM tapes, and dedicated acquisition chain (Enertec) including a format sync/decom and a programmable demultiplexer. The chain is controlled by an LSI-11 microprocessor and communicates with the computer and with the COMTAL system below, providing video, status and auxiliary data.

  - one COMTAL Color visualization system with a 512x512 screen, interactive keyboard and trackball, connected to the VAX and to the subsampled output port of the acquisition chain. This system supports the production of Quick-Look imagery (through a slave flatscreen display connected to the monitor and coupled to a Hasselblad camera) and also the interactive image manipulation facilities (contrast stretch, edge enhancement, etc) available in the processing system. These facilities operate over images previously loaded into the 256-MB disk dedicated to this role.

. one 5-inch film Electron Beam Recorder and special interface equipment (Image Graphics Inc.). This EBR is a second-generation device capable of both raster and vector drawing, with geometric fidelity rated at .01% and extended geometric corrections capability.

The software of the VAX system (developed jointly by SEP and INPE) incorporates both production and management functions, handling the creation and updating of an acquired + processed images data base, allowing inquiries and production scheduling based on user requests entered into the system.

The TM processing subsystem is currently being tuned to the Landsat-5 parameters and characteristics, and distribution of TM products to users is expected to start late June, 1984.

Besides the two processing subsystems above, there is a DEC PDP-11/34 minicomputer system, installed in 1978, supporting the management of the MSS and RBV data bases, as well as the inquiries and orders related to these instruments. It hosts also the geometric correction auxiliary functions for the production of Bulk and Precision photographic MSS imagery (this latter fully operational since early 1983).

2. Experience in Acquisition and Processing of LANDSAT 4/5 Data

2.1 - Receiving and recording

A few points deserve special notice in this area:

- The 'assisted tracking' implemented in the PDP-11/34 has not been necessary due to the absence of autotrack losses in normal operation. The employed model, however, has demonstrated superb performance in tests conducted by turning off the tracking receiver after the initial satellite acquisition. The computer took over controlling the antenna without loss of a single dB in the payload signals.
- The telemetry recorder had to be adapted to the new data rate of 8 Kbps, by using bi-phase instead of FSK recording.
- Landsat-4 TM data was never received due to the early failure of the TM transmitters. MSS was received and recorded with no problems.
- Landsat-5 TM is being routinely received and recorded since April 6, over the whole Brazilian territory (about 385 scenes/cycle). Due to the higher cost of recording and storing TM data, recording over other countries is planned to be subject of special arrangements between each interested country and Brazil.

2.2 - Processing

2.2.1 - MSS

Some problems faced in the processing deserved special attention:

- Some hardware modifications had to be carried on the MSS format sync equipment to accept the new S/C identification code inserted into the Time Code format.

- An old problem affecting all 24 MSS detectors was solved when it was noticed that with Landsat 4 the rate of its occurrence was considerably higher. This led to associate this problem with the increased Doppler effect due to the lower altitude of the satellite and trace it down to occasional single-bit losses at the Demultiplexer in Cuiaba. Another modification in the MSS format sync equipment corrected this problem for the processing.

- As in Cuiaba, the telemetry recorder had to be adapted to the new data rate of 8 Kbps. A modification in the recorder interface to the computer had to be implemented, as well as a rather deep change in the decommutation software.

- A heavy 'woodgrain effect' associated with detector coherent background noise was observed on Landsat-4 MSS data.

2.2.2 - TM

During the Final Acceptance tests, in the period from December/1983 to February/1984, several performance tests were conducted. Concerning geometric fidelity, it is worth to mention the results achieved in the geometric internal accuracy test. As a test image, the Toledo-Detroit Landsat-4 scene of July 25, 1982 was selected. The system geometric corrections were derived analytically and applied to the Electron Beam Recorder, benefiting from its ability to accept real-time corrections directly on its X-Y deflection circuitry. The full model (including jitter) was implemented into a UTM projection and 50 well-distributed geodetic GCPs were identified and measured. After removal of translational and rotational errors with respect to the UTM grid, the following encouraging performance data were verified:

Scale deviation :	.03 %
RMS error in Easting :	29.1 meters
RMS error in Northing :	24.6 meters
RMS error (total) :	38.1 meters

Note that this is just a system-corrected image!

From March to May/84, effort has been spent, mainly in the software area, to adjust the embedded satellite/instrument parameters to the new Landsat-5-specific coefficients/characteristics. Changes have also been made on the production routines towards a greater operationality when routinely processing real data onto Quicklook or high resolution EBR images, at real time rates.

On April/84 production of preliminary TM imagery was initiated in the high resolution film recorder with the main purpose of evaluating radiometric and geometric quality as well as image appearance.

During this preliminary production phase some apparent anomalies were observed:

- A banding effect, in phase with scan rate, visible mainly on uniform radiance areas, has been seen and thought to be related with the Scan Line Corrector performance. It was not observed in the Detroit image, at 40 degrees North latitude. This problem is still being studied to confirm or not this possibility. In the meantime, images are being processed with a geometric correction level slightly lower, to force parallelism between forward and reverse scans. This has eliminated the banding effect without causing noticeable local distortions.

- A severe along-line shift between forward and reverse scans can be observed in band 6 (thermal). The problem is still under investigation.

- Concerning radiometric performance, a definite need has been felt for some kind of contrast stretch treatment on data of most TM bands prior to processing them onto film. The attempt to process these bands to film without such enhancements has resulted into very flat images with poor image detail. This situation is aggravated due to the linear gamma transfer function presently in use in the EBR. All bands except 4 and 5 will require special look-up tables derived to accomodate the average radiance excursion of each band within the most favorable dynamic range of the film but avoiding, as much as possible, cutoff or saturation of the data. The intention is to combine linear look-up tables in the computer with a nonlinear gamma transfer function at the EBR to achieve this improvement. In this preliminary phase, tests are being conducted to select the best gain and offset combination for each band for the use of linear look-up tables alone. The nonlinear gamma transfer function on the EBR will be implemented in the near future, and new gain/offset pairs may be required then.

ANNEX B - TABLE UPDATES

1. Station Plans for TM Reception and Products

LGSOWG MEMBER	RECEPTION CAPABILITY DATE	DESIRED ACQUISITION LEVEL	OPERATIONAL PROCESSING DATE	PLANNED OUTPUT PRODUCTS		
				TYPE	VOLUME	FORMAT
Brazil (INPE)	February 1983	Complete coverage of Brazil (385 scenes/ cycle) as first priority; additional coverage depending on support from other countries.	March 1984	Quicklook	Full acquisition	Earth rotation corrected
			June 1984	Bulk film	10 scenes/day	System corrected
			July 1984	CCT	2 scenes/week	Radiometrically corrected; along-line corrections applied; full frame or quadrant; BIL or BSQ.
			Late 1984	Precision film	1 scene/week	System corrected + GCPs

2. Implementation Schedule for Data Formats Employing Superstructure Conventions

COUNTRY/ AGENCY	SUPERSTRUCTURE FORMAT DATA CONTENT	INITIAL DATE OFFERED	NOTES
Brazil/INPE	Landsats 1-4 MSS, BIP2	Jan/1982 (a)	a. Superstructured BIP2 format discontinued due to absence of requests. The old non-superstructured BIP2 format will be kept available to support users with existing applications commited to it.
	Landsats 4-5 MSS, BIL/BSQ	Mid-1984	
	Landsat 5 TM, BIL/BSQ	Mid-1984 (b)	b. Initially TM CCTs will have only along-line geometric corrections applied.

ANNEX C - WORLDWIDE REFERENCE SYSTEMS: A CALL FOR STANDARDIZATION

Since Landsat D came to stage with a new coverage pattern, the concept of the Worldwide Reference System, ideally suited for repetitive satellite coverage, began to face its first problems. We have now two Worldwide Reference Systems instead of one and, with the several other satellites expected to be launched in years to come, some confusion is likely to arise if the WRS concept is not revised.

At INPE we have got used to refer to the two existing WRSs as the 'old' and the 'new' ones, instead of using the full names of 'WRS of Landsats 1,2 and 3' and 'WRS of Landsat 4' (which, by the way, should now be changed to mention also Landsat 5). Needless to say that a third system would invalidate these nicknames.

The next remote sensing satellite available to the international user community will be expectedly the french SPOT. For this satellite, with its side-looking capability, the concepts of Paths and Rows will be definitely inadequate.

Therefore, evidence seems to point to a geographically-oriented WRS, independent from any particular coverage pattern, as a long term solution to allow users to specify their area of interest in a reasonably concise form.

Some countries have already geocoded products based on a chart index, which gave to the output of their systems this characteristic of universality. What we feel the need for, however, is an international consensus, perhaps to be presented to the LGSOWG, on a recommendation for a geographic WRS that all countries could use and would fit not only all Landsats but future satellites as well.

In our point of view, this system should have the following characteristics:

- be simple to explain, to represent and to use;

- have a 'resolution' of 15′ (approx. 30km at the Equator) to allow good separation of scene centers for images like SPOT′s (60x60km) and also that users can express more precisely the location of their areas of interest, but support also the specification of larger areas;

- stand above national chart indexing conventions and avoid the somewhat confusing articulation rules of the international World Geographic Reference System (NF23-Y-A-IV-3, etc.).

A possible implementation, given herein to illustrate the points above, is that we keep the well-known East-West/North-South latitude and longitude scheme to define a 1-degree grid, and subdivide each cell in 4x4 subcells of 15', addressed by a pair of 4-valued codes, one code for X and one for Y. If we defined these 4 values as A,B,C and D, for example, Sao Jose dos Campos (S23:10/W45:53) would be in 'Path' S23A/'Row' W45D. A Landsat-5 scene showing the city (Path 218/Row 76 of the Landsats 4 and 5) would be coded as S23A/W45A for its scene center at S23:06/W45:00.

A special code denoting 'range' of interest or coverage could be also defined to give an idea of the size of a scene or the extension of an area of interest whose center is expressed in this WRS. This range code should be expressed in terms of distance rather than in coordinates, due to the convergence of meridians, and correspond to a nonlinear sequence (like 10, 20, 50, 100, 200) to limit the number of ranges. The code could be applied optionally to each direction or both, depending on the convenience of specifying this information and also on whether the image or the area extends beyond or is smaller than the subcell containing its center. For instance: the Landsat 5 scene over Sao Jose dos Campos mentioned above, sized about 185x185 Km, could be coded as S23Ae/W45Ae if 'e' denoted a range on the order of 200 Km; the city itself could be described by S23Aa/W45Da if 'a' was associated to a 10-Km range and one desired to specify the approximate size of the city.

If a geographic WRS such as the one above is defined, it will become the third (and hopefully the last) one 'in scene'. We suggest that short and unequivocal names be assigned to each one in order that confusion among them is minimized, mainly between the first two, by always prefixing the WRS name to the Path and Row codes. Just for illustration, let's say that WRS-A, WRS-B and WRS-G (for Geographic) are the names. We would have then Sao Jose dos Campos as WRS-A 234/76, WRS-B 218/76 or WRS-G S23A/W45A. The use of the geographic WRS should anyway be encouraged among the user community, even for early imagery.

It was our feeling that the LTWG would be the best forum to discuss and convey upon the subjects above. Therefore, our suggestion is that a subgroup be appointed with this task, for presentation at the next LGSOWG meeting if so agreed.

ANNEX D -- PRELIMINARY PRICE LIST

LANDSAT DATA -- THEMATIC MAPPER (TM)

ATTENTION: Prices include the NOAA distribution fee of US$25.00 for each photographic product and US$ 300.00 for each complete scene in digital form. This fee does not apply to Quick-look products.

The prices herein are subject to change without notice. The intended validity is until October 31, 1984.

PHOTOGRAPHIC PRODUCTS

A) Quick-Look products (uncorrected/low resolution images meant for cloud cover and quality evaluation; available in just one spectral band, generally Band 3; scale and size approximate)

Scale	Medium	Size	Code	Price(US$)
1:4,000,000	Paper	40mm	0120	3.00

B) Bulk products (System-corrected geometrically and radiometrically; Sun elevation-compensated)

B.1) Black-and-white

Scale	Medium	Size	Code	Price(US$)
1:1,000,000	Film negative	185mm	0202	110.00
1:1,000,000	Film positive	185mm	0212	100.00
1:1,000,000	Paper	185mm	0222	75.00
1:500,000	Paper	370mm	0223	140.00
1:250,000	Paper	740mm	0224	250.00

B.2) Color (normal band usage 2/3/4 for false color and 1/2/3 for true color)

Scale	Medium	Size	Code	Price(US$)
1:1,000,000	Film positive	185mm	1212	200.00
1:1,000,000	Paper	185mm	1222	180.00
1:500,000	Paper	370mm	1223	240.00

Additional fee for band combinations different from the above (master color negative retained): US$100.00.

(over)

DIGITAL PRODUCTS (system-corrected just radiometrically; geometric corrections along line only)

A) Full frame (n = number of bands, from 1 to 7)

Format	Density	Tapes	Code	Price (US$)
BIL	1600 bpi	n*2400'	201n	100.00 + n * 550.00
BSQ	1600 bpi	n*2400'	203n	100.00 + n * 550.00

B) Quadrant (3-band or 7-band only)

Bands	Format	Density	Tapes	Code	Price (US$)
3	BIL	1600 bpi	1*2400'	2053	600.00
3	BSQ	1600 bpi	1*2400'	2073	600.00
7	BIL	1600 bpi	2*2400'	2057	1300.00
7	BSQ	1600 bpi	2*2400'	2077	1300.00

NOTES:

1) Payments must be made in advance through a nominal check to Instituto de Pesquisas Espaciais. An account can also be maintained for quickest servicing.

2) Prices include airmail delivery for photographic products; CCTs are normally airfreighted collect.

3) Normal servicing time is 10-15 days; CCTs can suffer an additional 10-20 days delay to obtain the necessary export license.

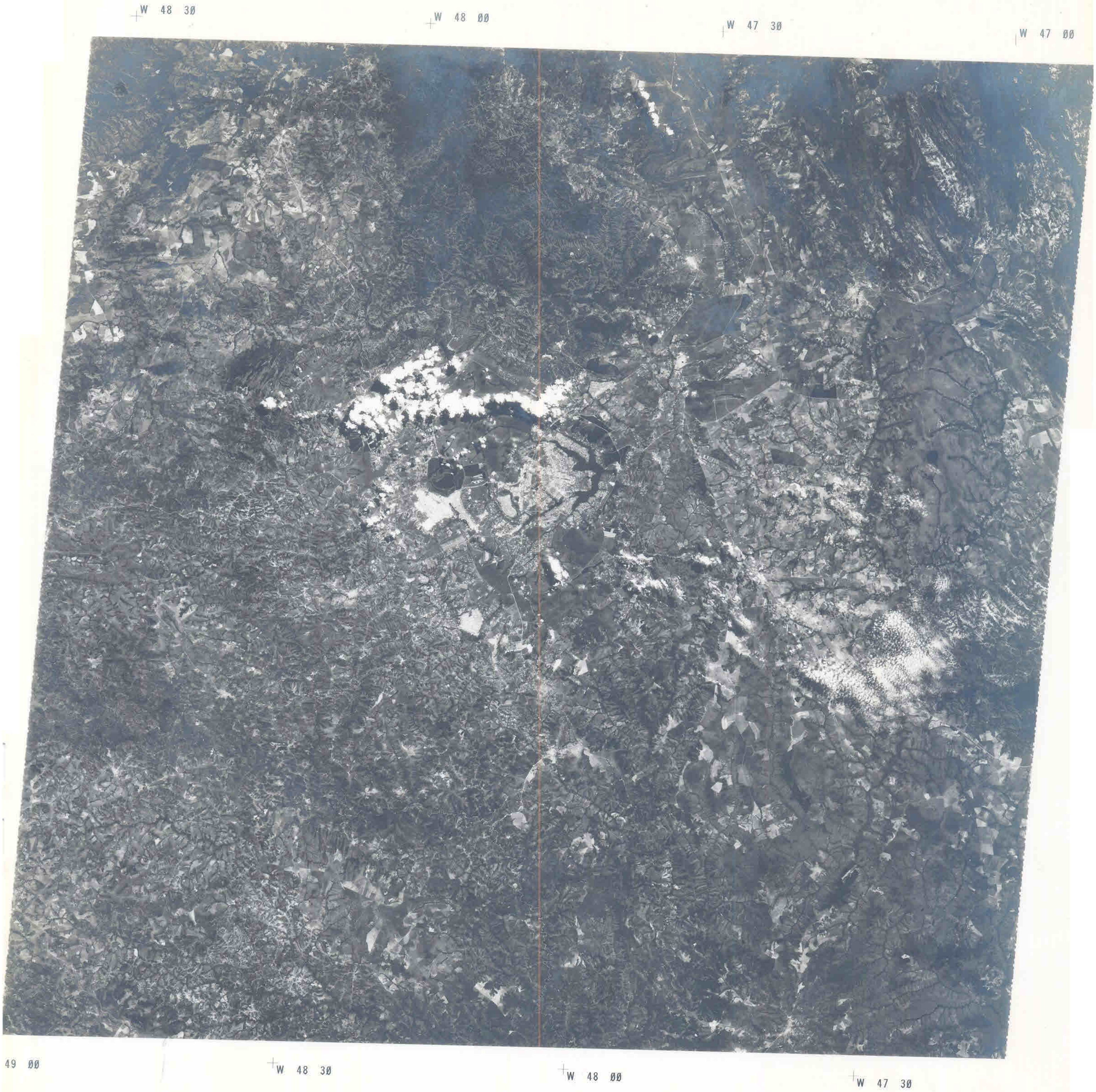
June 1984

Nelson de Jesus Parada
Director General

ANNEX E

LANDSAT 5 - TM SCENE, CHANNEL 3, APRIL 24/1984

(BRASILIA AREA)



BRASIL-CNPq/INPE

221DØ71

TM5-ØØ784-TØ25

24ABR84 WRS: 221DØ71 HDE C: S15:54/WØ47:54
SOM G=3 E=6 184x185km N: S15:53/WØ47:54

TM - LANDSAT 5
BANDA(S): ▮▮3▮▮▮▮

SOL: EL43 AZØ54 R189
R=2 CES GAMA=Ø QG=99

T/C: 84115-124153.Ø
PROC Ø6JUN84 14:23
TRAT(S): AC