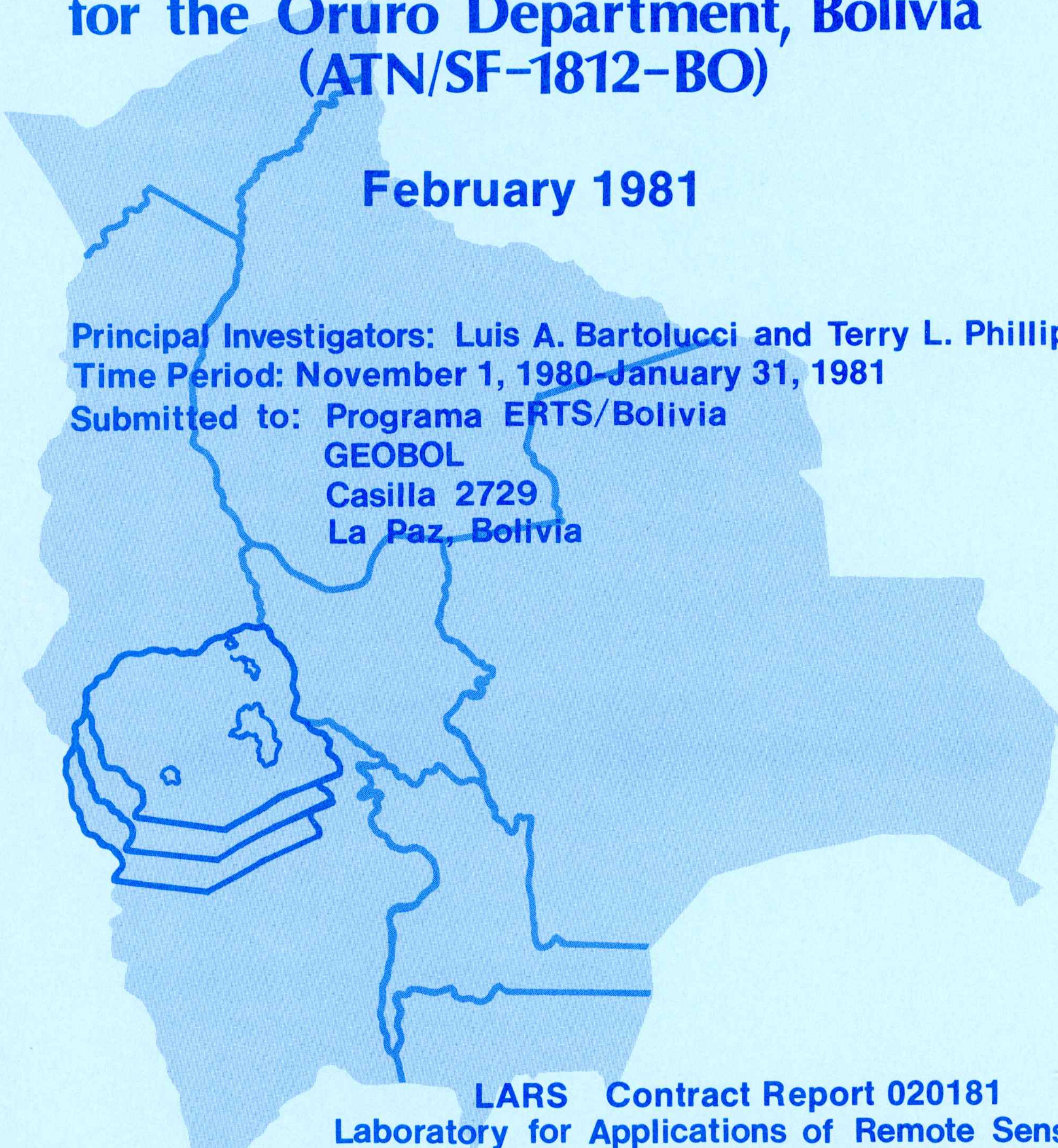
Quarterly Progress Report

Digital Information System for the Oruro Department, Bolivia (ATN/SF-1812-BO)

February 1981



Principal Investigators: Luis A. Bartolucci and Terry L. Phillips

Time Period: November 1, 1980-January 31, 1981

Submitted to: Programa ERTS/Bolivia
GEOBOL
Casilla 2729
La Paz, Bolivia

LARS Contract Report 020181
Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906
USA

QUARTERLY PROGRESS REPORT

Period: November 1, 1980-January 31, 1981

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Oruro Department, Bolivia (ATN/SF-1812-BO)

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Digital Geographic Information System for the Oruro Department, Bolivia

INTRODUCTION

As indicated in the time table of the proposed project implementation plan illustrated in Figure 1, a number of tasks of this project have already been completed and the results have been documented in the previous Quarterly Progress Report corresponding to the time period August 1, 1980-October 31, 1980.

During the present reporting period, i.e., November 1 through January 31, a great deal of work, including research and development was carried out in order to accomplish the project tasks related to a) the creation of the Landsat digital mosaic, b) the specification of the data base elements (coding), and c) the input of the data base elements.

CREATION OF THE LANDSAT DIGITAL MOSAIC

Problems Encountered

According to the time table of the original implementation plan (Figure 1 in the Quarterly Progress Report for the period August 1, 1980-October 31, 1980), the 7 Landsat scenes that cover the Oruro department and the appropriate control points were to be delivered to the NASA Jet Propulsion Laboratory (JPL) on October 1, 1980. However, as indicated in the previous Quarterly Progress Report, a number of unforeseen problems were encountered, related to the Landsat data quality and the control points provided by the Bolivian ERTS Program.

TIME TABLE (in months)

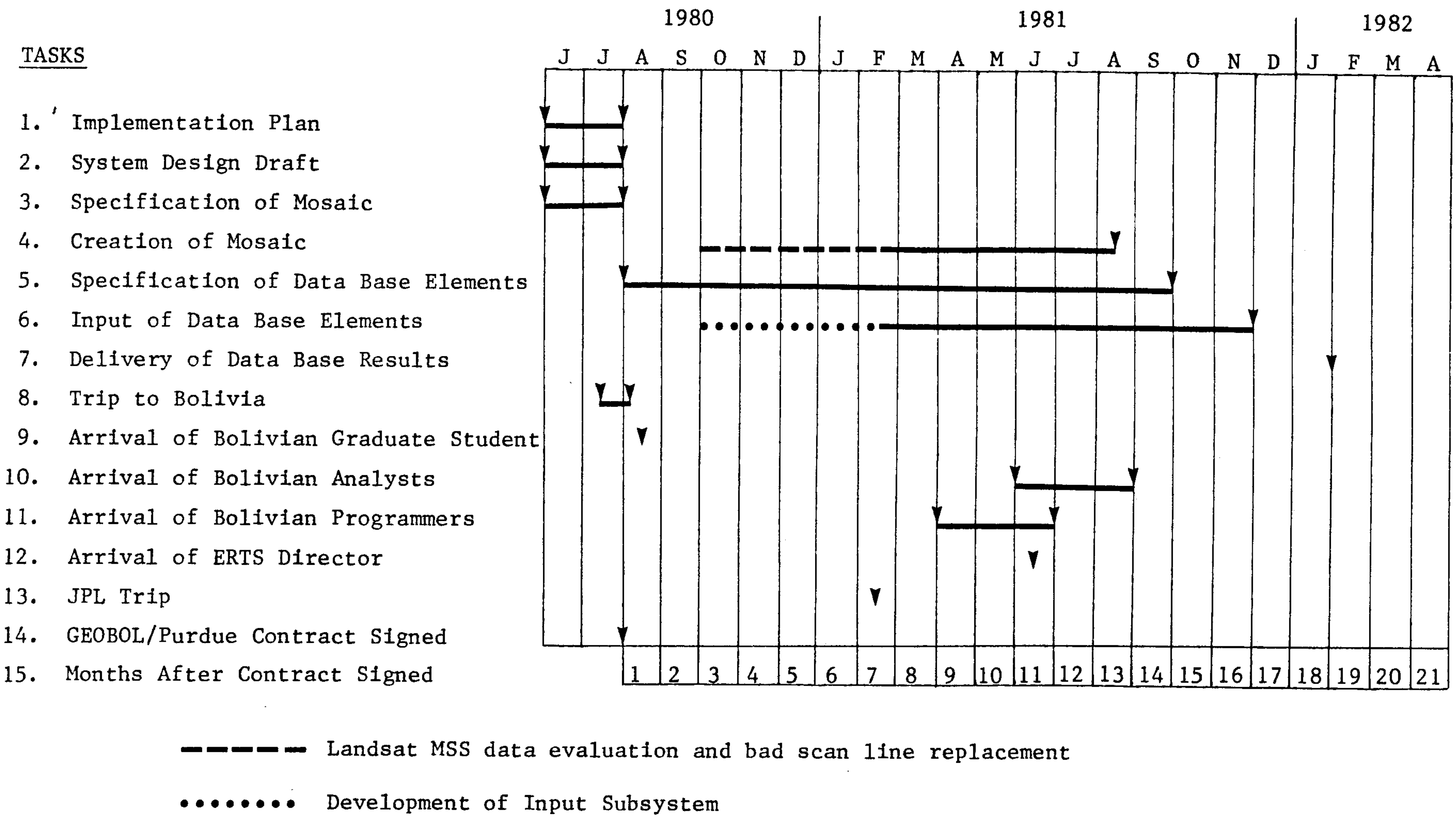

Figure 1. Proposed Project Implementation Plan (as of January 31, 1981).

In order to solve these problems, a thorough evaluation of the Landsat data quality had to be performed, and new control points had to be selected. These two extra and time consuming activities were completed during the last week of January 1981, thus delaying the delivery of the data to JPL by approximately four months.

Evaluation of the Landsat MSS Data Quality

The seven Landsat MSS frames provided by the Bolivian ERTS Program, in the form of 14 800 BPI computer compatible magnetic tapes, were purchased from the Brazilian National Institute of Space Research (INPE) since these data were received at the Cuiaba, Brazil Landsat receiving station. As described in the previous Quarterly Progress Report, four of the seven scenes could not be successfully read or copied because of "read errors" in certain scene strips. This problem was solved by replacing the "bad data lines" as indicated in Tables 3 and 4 of the Quarterly Progress Report corresponding to the period August 1, 1980-October 31, 1980. When all the tapes could be read, each Landsat scene was reformatted to both a NASA and a LARSYS format using the INPERTS and REFERTS software programs developed at LARS.

A preliminary assessment of the quality of the Landsat imagery generated from the INPE CCT's revealed a number of severe data quality problems. These types of problems had never been seen in any of the approximately 3000 Landsat scenes available at LARS and which were obtained from the EROS Data Center.

One of these Landsat data quality problems is shown in Figure 2. Note the vertical "bars" of alternating dark and light tones, which have a height of 6 scan lines and do not represent any real features on the ground. These "bars" were found in all the seven frames that cover the Oruro Department.

RUN NUMBER........... 76022500
FLIGHT LINE... 540913134 BOLI
DATA TAPE/FILE NUMBER.. 2836/ 3
REFORMATTING DATE. SEPT 17,1980

DATE DATA TAKEN... JUNE 5,1977
TIME DATA TAKEN..... 0813 HOURS
PLATFORM ALTITUDE..3062000 FEET
GROUND HEADING..... 189 DEGREES

CHANNEL 2 SPECTRAL BAND 0.60 TO 0.70 MICROMETERS

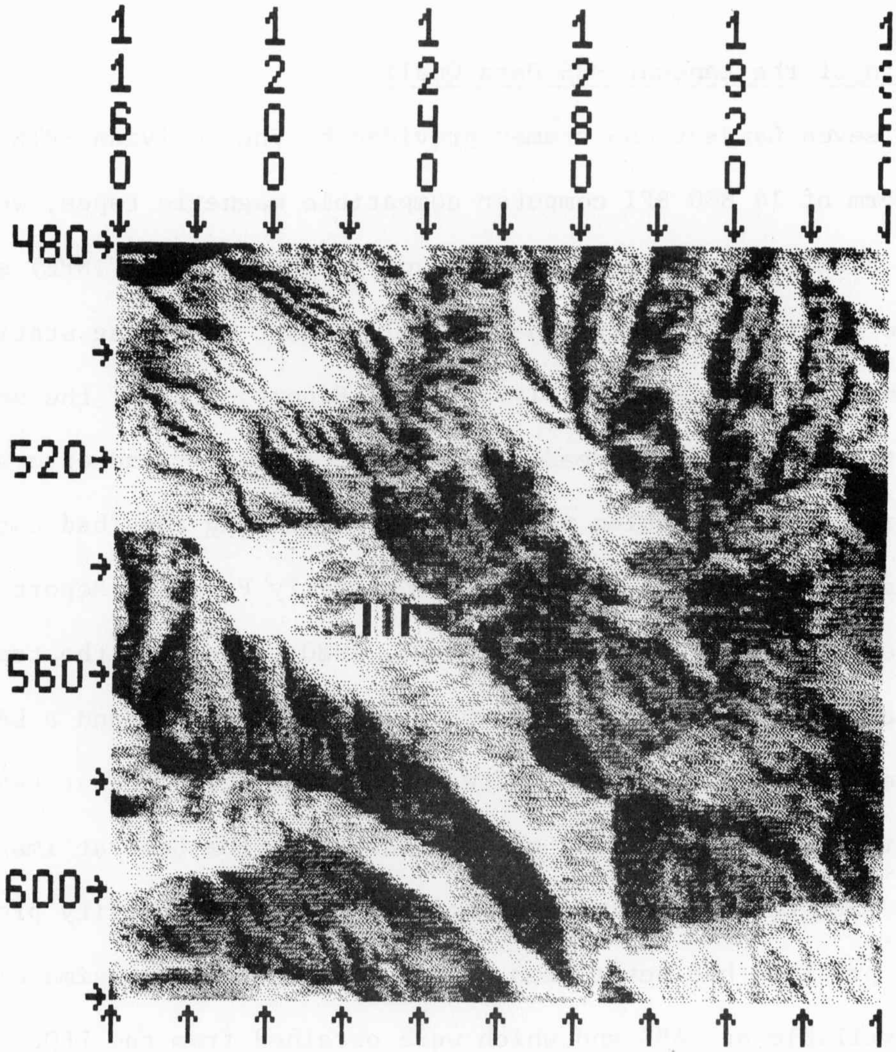

Figure 2. Portion of the Oruro Landsat Frame showing data quality problems. Note the vertical alternating light and dark "bars" and the 6-scan line repetition problems.

However, the major problem is not the presence of the "bars" themselves, but the fact that every place where they occur, there is a repetition of six scan lines across one or more of the eight strips that form a complete Landsat scene. The 6-line data repetition problem is clearly illustrated in Figure 2. Table 1 shows a listing of the actual digital values (digital counts) in the four Landsat MSS bands of every pixel in a block of data which includes the area where the "bars" shown in Figure 2 are located*. This block of data is located between line 547 and line 552, and between column 1220 and column 1240. Note in Table 1 that for the sequence of scan lines 547 to 552 (six contiguous scan lines), a series of zero and larger than normal scene (> 100) digital values are present in all the four Landsat MSS spectral bands, which produced the dark and light "bars" shown in Figure 2.

Close inspection of the 6-line repetition problem revealed that these scan lines were repeated because 6 lines of actual data were missing. Therefore, there was no way to solve this problem and both the "bars" and repeated scan lines were left uncorrected.

Another data quality problem encountered in all the seven Landsat frames covering the Oruro Department is shown in Figure 3. This data quality problem referred to as "striping effect", generally caused by malfunctions (bit drop) of one of the six Landsat MSS detectors, was solved through the replacement of the "bad scan lines" by the nearest (usually the previous) good quality scan line. Figure 4 shows the same area shown in Figure 3, except that in Figure 4 the "bad scan lines" had been replaced. Comparison of these two figures clearly shows the tremendous improvement in the quality of the imagery.

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* Note in Table 1 that there are digital values greater than 127 in all four Landsat MSS bands. This is due to the fact that the dynamic range of the Brazilian INPE data has been expanded to 8 bits (0-255).

Table 1. Digital Values for a Block of Landsat MSS Data containing the "Bar" Quality Problem.

		MSS Bands			
Line	Col.	4	5	6	7
547	1220	23.0	12.0	24.0	53.0
547	1221	26.0	17.0	31.0	62.0
547	1222	32.0	25.0	39.0	67.0
547	1223	156.0	64.0	20.0	0.0
547	1224	144.0	52.0	12.0	16.0
547	1225	0.0	0.0	141.0	180.0
547	1226	0.0	0.0	12.0	164.0
547	1227	84.0	48.0	0.0	0.0
547	1228	76.0	36.0	16.0	0.0
547	1229	0.0	141.0	232.0	176.0
547	1230	0.0	12.0	208.0	80.0
547	1231	68.0	0.0	0.0	0.0
547	1232	56.0	16.0	0.0	0.0
547	1233	141.0	112.0	72.0	20.0
547	1234	12.0	88.0	24.0	12.0
547	1235	0.0	0.0	0.0	141.0
547	1236	16.0	0.0	0.0	12.0
547	1237	18.0	7.0	0.0	9.0
547	1238	18.0	4.0	0.0	18.0
547	1239	18.0	7.0	0.0	14.0
547	1240	18.0	7.0	0.0	14.0
548	1220	32.0	29.0	40.0	62.0
548	1221	32.0	32.0	42.0	71.0
548	1222	32.0	29.0	51.0	80.0
548	1223	164.0	72.0	28.0	0.0
548	1224	156.0	64.0	16.0	16.0
548	1225	0.0	0.0	141.0	172.0
548	1226	0.0	0.0	12.0	160.0
548	1227	76.0	44.0	0.0	0.0
548	1228	68.0	32.0	16.0	0.0
548	1229	0.0	141.0	192.0	140.0
548	1230	0.0	12.0	168.0	56.0
548	1231	48.0	0.0	0.0	0.0
548	1232	44.0	16.0	0.0	0.0
548	1233	141.0	108.0	64.0	16.0
548	1234	12.0	84.0	16.0	12.0
548	1235	0.0	0.0	0.0	141.0
548	1236	16.0	0.0	0.0	12.0
548	1237	27.0	18.0	12.0	23.0
548	1238	21.0	7.0	0.0	10.0
548	1239	18.0	4.0	0.0	14.0
548	1240	18.0	7.0	0.0	14.0
549	1220	34.0	30.0	41.0	71.0
549	1221	34.0	30.0	48.0	71.0
549	1222	34.0	33.0	52.0	83.0
549	1223	172.0	76.0	28.0	0.0
549	1224	160.0	64.0	16.0	16.0
549	1225	0.0	0.0	141.0	172.0
549	1226	0.0	0.0	12.0	160.0
549	1227	76.0	40.0	0.0	0.0
549	1228	64.0	24.0	16.0	0.0
549	1229	0.0	141.0	184.0	136.0
549	1230	0.0	12.0	164.0	56.0
549	1231	48.0	0.0	0.0	0.0
549	1232	40.0	16.0	0.0	0.0
549	1233	141.0	124.0	68.0	16.0
549	1234	12.0	92.0	20.0	12.0
549	1235	0.0	0.0	0.0	141.0
549	1236	16.0	0.0	0.0	12.0
549	1237	46.0	44.0	43.0	58.0
549	1238	32.0	25.0	20.0	30.0
549	1239	19.0	9.0	0.0	13.0
549	1240	17.0	6.0	0.0	9.0

Table 1. (Continued)

MSS Bands

Line	Col.	4	5	6	7
550	1220	31.0	26.0	31.0	55.0
550	1221	31.0	28.0	38.0	64.0
550	1222	28.0	28.0	44.0	68.0
550	1223	160.0	64.0	20.0	0.0
550	1224	148.0	52.0	8.0	16.0
550	1225	0.0	0.0	141.0	188.0
550	1226	0.0	0.0	12.0	168.0
550	1227	84.0	48.0	0.0	0.0
550	1228	76.0	36.0	16.0	0.0
550	1229	0.0	141.0	168.0	120.0
550	1230	0.0	12.0	148.0	48.0
550	1231	44.0	0.0	0.0	0.0
550	1232	32.0	16.0	0.0	0.0
550	1233	141.0	96.0	56.0	12.0
550	1234	12.0	76.0	12.0	12.0
550	1235	0.0	0.0	0.0	141.0
550	1236	16.0	0.0	0.0	12.0
550	1237	40.0	38.0	44.0	59.0
550	1238	37.0	35.0	36.0	51.0
550	1239	31.0	21.0	20.0	34.0
550	1240	23.0	14.0	5.0	18.0
551	1220	24.0	14.0	23.0	48.0
551	1221	21.0	11.0	17.0	41.0
551	1222	21.0	11.0	17.0	41.0
551	1223	140.0	56.0	20.0	0.0
551	1224	128.0	52.0	8.0	16.0
551	1225	0.0	0.0	141.0	176.0
551	1226	0.0	0.0	12.0	160.0
551	1227	76.0	40.0	0.0	0.0
551	1228	68.0	28.0	16.0	0.0
551	1229	0.0	141.0	180.0	132.0
551	1230	0.0	12.0	164.0	52.0
551	1231	48.0	0.0	0.0	0.0
551	1232	40.0	16.0	0.0	0.0
551	1233	141.0	104.0	64.0	12.0
551	1234	12.0	80.0	16.0	12.0
551	1235	0.0	0.0	0.0	141.0
551	1236	16.0	0.0	0.0	12.0
551	1237	31.0	24.0	43.0	67.0
551	1238	31.0	27.0	39.0	59.0
551	1239	38.0	35.0	39.0	59.0
551	1240	44.0	38.0	47.0	63.0
552	1220	24.0	12.0	15.0	39.0
552	1221	22.0	12.0	9.0	28.0
552	1222	22.0	9.0	7.0	28.0
552	1223	168.0	72.0	28.0	0.0
552	1224	156.0	64.0	16.0	16.0
552	1225	0.0	0.0	141.0	184.0
552	1226	0.0	0.0	12.0	164.0
552	1227	84.0	48.0	0.0	0.0
552	1228	72.0	32.0	16.0	0.0
552	1229	0.0	141.0	176.0	132.0
552	1230	0.0	12.0	164.0	56.0
552	1231	48.0	0.0	0.0	0.0
552	1232	36.0	16.0	0.0	0.0
552	1233	141.0	116.0	68.0	16.0
552	1234	12.0	88.0	16.0	12.0
552	1235	0.0	0.0	0.0	141.0
552	1236	16.0	0.0	0.0	12.0
552	1237	32.0	27.0	37.0	62.0
552	1238	34.0	29.0	35.0	59.0
552	1239	36.0	34.0	41.0	62.0
552	1240	39.0	41.0	48.0	74.0

RUN NUMBER............ 76022400
FLIGHT LINE... 540913140 BOLI
DATA TAPE/FILE NUMBER.. 3769/ 1
REFORMATTING DATE. SEPT 17,1980

DATE DATA TAKEN... JUNE 5,1976
TIME DATA TAKEN..... 0814 HOURS
PLATFORM ALTITUDE..3062000 FEET
GROUND HEADING..... 190 DEGREES

CHANNEL 1 SPECTRAL BAND 0.50 TO 0.60 MICROMETERS

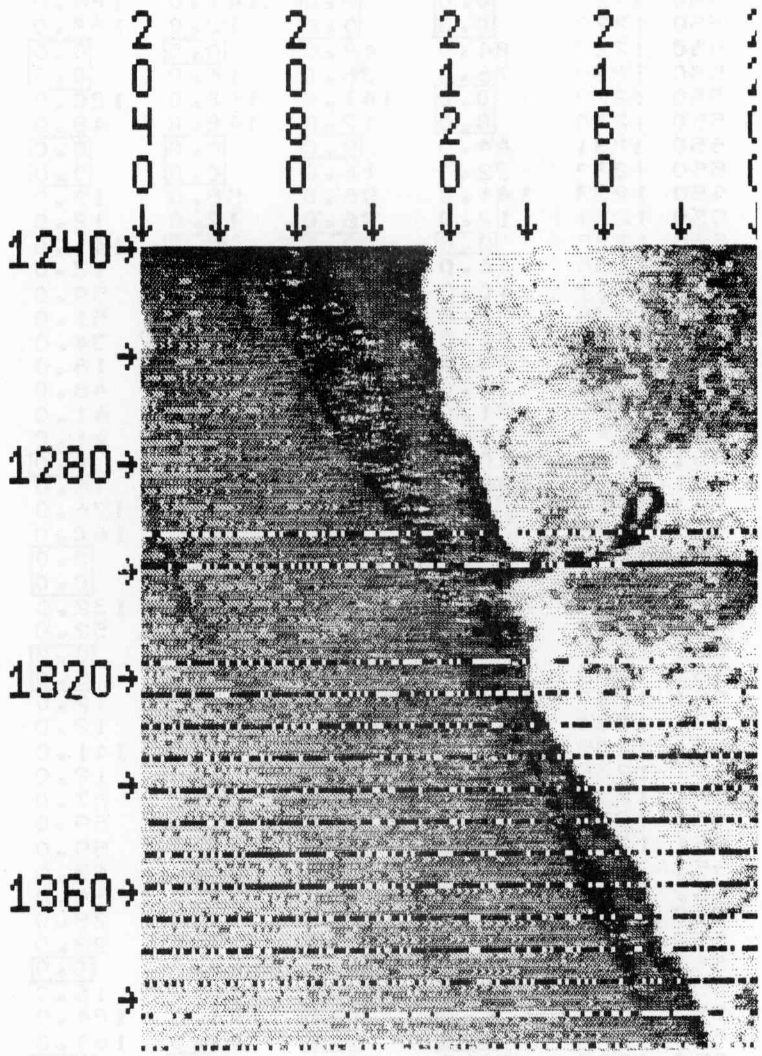

Figure 3. A portion of the Lago Poopo Landsat frame showing the data quality problem referred to as "striping effect".

RUN NUMBER............ 76022401
FLIGHT LINE... 540913140 BOLI
DATA TAPE/FILE NUMBER.. 3759/ 1
REFORMATTING DATE. FEB 9,1981

DATE DATA TAKEN... JUNE 5,1976
TIME DATA TAKEN..... 0814 HOURS
PLATFORM ALTITUDE..3062000 FEET
GROUND HEADING..... 190 DEGREES

CHANNEL 1 SPECTRAL BAND 0.50 TO 0.60 MICROMETERS

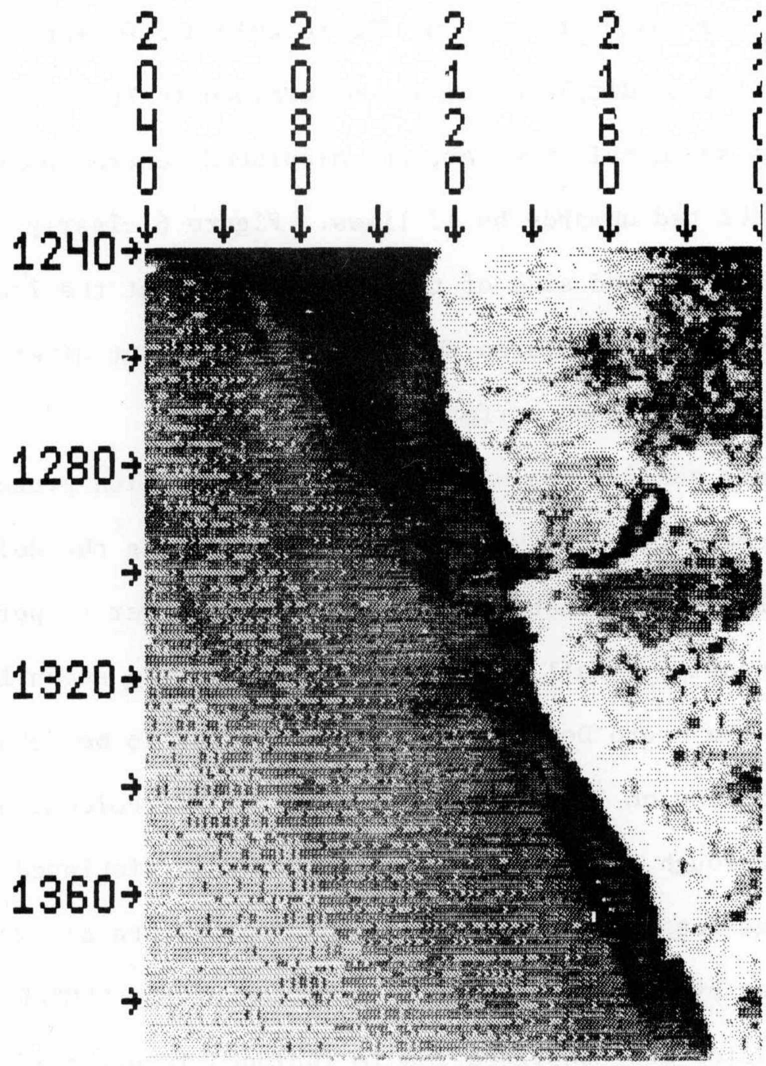

Figure 4. A portion of the Lago Poopo Landsat frame (same area shown in Figure 3) showing the tremendous improvement in the quality of the image after a replacement of the "bad scan lines" was performed.

Table 2 contains a list of all the "bad scan lines" that had to be replaced in order to improve the visual quality of the Oruro Department Landsat imagery. Appendix A also includes this information in addition to the standard LARS Data Storage Tape File information (LARS FORM 17D).

The most severe data quality problem was encountered in the Oruro Landsat MSS frame. This problem consisted of a downward displacement of the central portion of the image from column 790 to column 2382 (see Figure 5). The magnitude of this displacement was determined to be of 12 lines. Therefore, in order to solve this problem, the displaced central portion of the frame had to be shifted upwards by 12 lines. Figure 6 clearly shows the downward shift of the lefthand side of the data occuring at the location of column 2382. Figure 7 shows the same area shown in Figure 6, but after the correction (upward shift) had been performed.

The data quality evaluation and data correction process turned out to be an extremely time consuming task, thus delaying the delivery of the data sets to JPL by approximately four months. In order to perform a thorough visual inspection of all the data contained in the seven Landsat MSS frames that cover the Oruro Department, each frame had to be subdivided and reformatted into 35 subareas no larger than 512 lines by 512 columns as illustrated in Figures 8 through 14. These subareas were then displayed in a COMTAL Vision One/20 image display device, which can display data blocks of a maximum size of 512 lines by 512 columns. A description of the COMTAL Vision One/20 characteristics and configuration is included in Appendix B of this report.

Since all four spectral bands of each of the 35 subareas for each of the seven frames covering the Oruro Department had to be carefully inspected, the total number of subscenes that had to be evaluated was 4 x 35 x 7 = 980.

Table 2. "Bad Scan Lines" That Had to be Replaced in All the Seven Landsat Frames Covering the Oruro Department.

DESAGUADERO FRAME

LARS Run Number

Before Correction: (77010500) After Correction: (77010501)

Line Numbers

Channel 1	Channel 2	Channel 3		Channel 4
1017	329	253	1053	
	1474	353	1309	
		478	1322	
		545	1394	
		721	1641	
		1039	1849	

SALAR DE COIPASA FRAME

LARS Run Number

Before Correction: (77010600) After Correction: (77010601)

Line Numbers

Channel 1	Channel 2	Channel 3		Channel 4
2212	798	973	1201	930
2317	1284	1009	1207	1360
		1015	1509	2149
		1046	2167	
		1105	2209	
		1111	2221	
		1135	2317	

Table 2. (Continued)

LAGO POOPO FRAME

LARS Run Number

Before Correction: (76022400) After Correction: (76022401)

Line Numbers

Channel 1		Channel 2		Channel 3	Channel 4
54	384	24	323	1395	
240	623	54	353		
264	624	114	383		
324	894	234	623		
354		258	1163		
(1293, 1473, 6)		264	1974		
		293			
		(2255, 2339, 6)			

SUCRE FRAME

LARS Run Number

Before Correction: (79005800) After Correction: (79005801)

Line Numbers

Channel 1	Channel 2	Channel 3	Channel 4	
100	640	345	100	904
	2263	535	185	1192
		1550	304	1252
			323	1312
			364	1313
			415	1654
			416	1924
			523	1960
			640	1981
			772	2223
			808	2224
			868	2284
			892	2338

Table 2. (Continued)

SALAR DE EMPEXA FRAME

LARS Run Number

Before Correction: (77010700) After Correction: (77010701)

Line Numbers

Channel 1	Channel 2	Channel 3		Channel 4
97	411	43	1699	580
129	1368	247	1868	1072
693	1649	416	1987	
	2131	1668	2185	
	2250	1688		

SALAR DE UYUNI FRAME

LARS Run Number

Before Correction: (77010300) After Correction: (77010301)

Line Numbers

Channel 1		Channel 2	Channel 3	Channel 4
1002	1534	2047	1460	
1033	1565	2052	1503	
1129	1573		1509	
1145	1581		1629	
1259	1597			
1321	1633			
1517				

Table 2. (Continued)

ORURO FRAME

LARS Run Number

Before Correction: (76022500) After Correction: (76022501)

Line Numbers

Channel 1	Channel 2	Channel 3	Channel 4

Shift by 12 lines the entire central block of the Landsat scene from columns: 790 to 2382

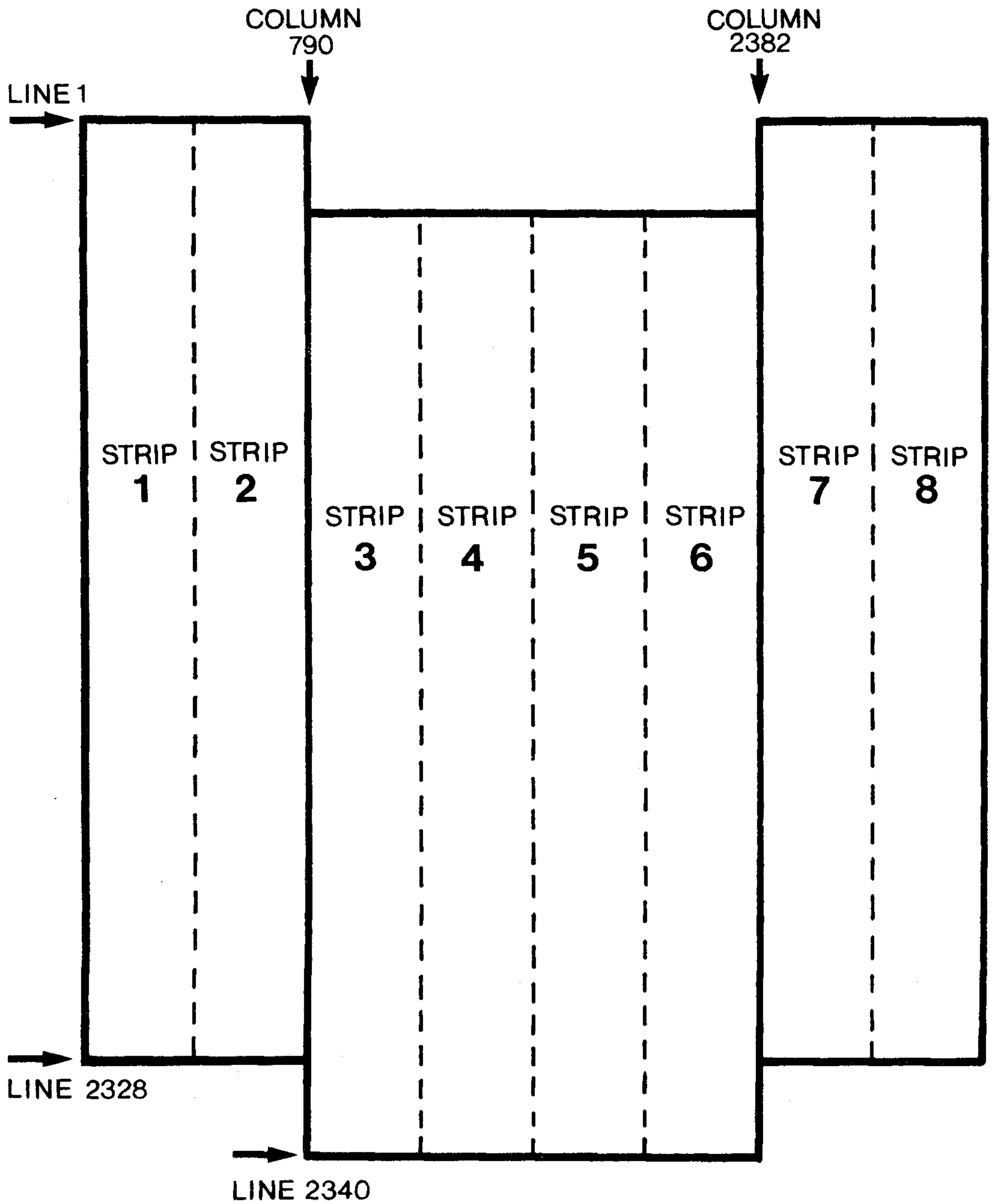

Figure 5. Downward displacement of the central portion of the Oruro Landsat frame.

RUN NUMBER............ 76022500

FLIGHT LINE... 540913134 BOLI

DATA TAPE/FILE NUMBER.. 2836/ 3

REFORMATTING DATE. SEPT 17,1980

DATE DATA TAKEN... JUNE 5,1977

TIME DATA TAKEN..... 0813 HOURS

PLATFORM ALTITUDE..3062000 FEET

GROUND HEADING..... 189 DEGREES

CHANNEL 2 SPECTRAL BAND 0.60 TO 0.70 MICROMETERS

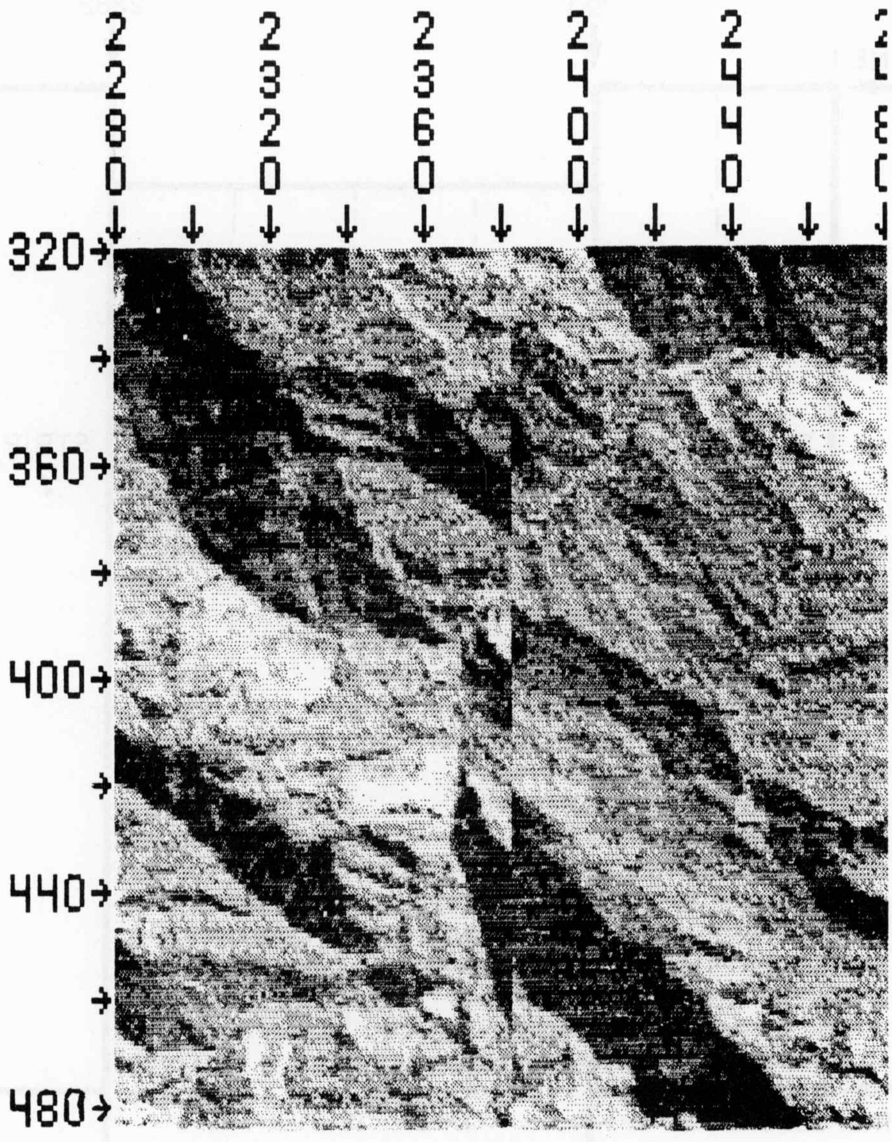

Figure 6. A portion of the Oruro Landsat frame showing the downward displacement of the data on the left hand side of the image.

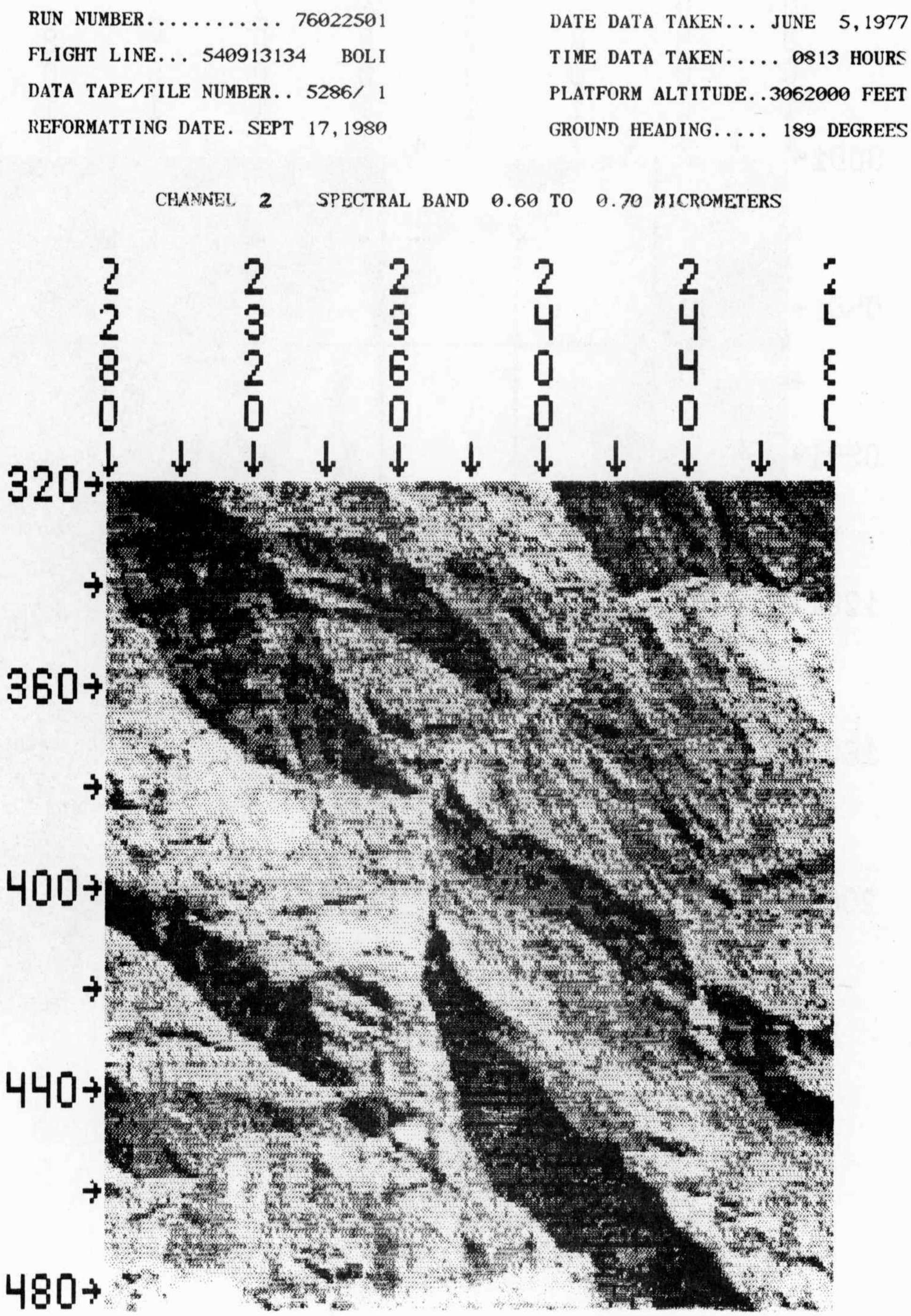

Figure 7. Corrected image corresponding to the same area shown in Figure 5.

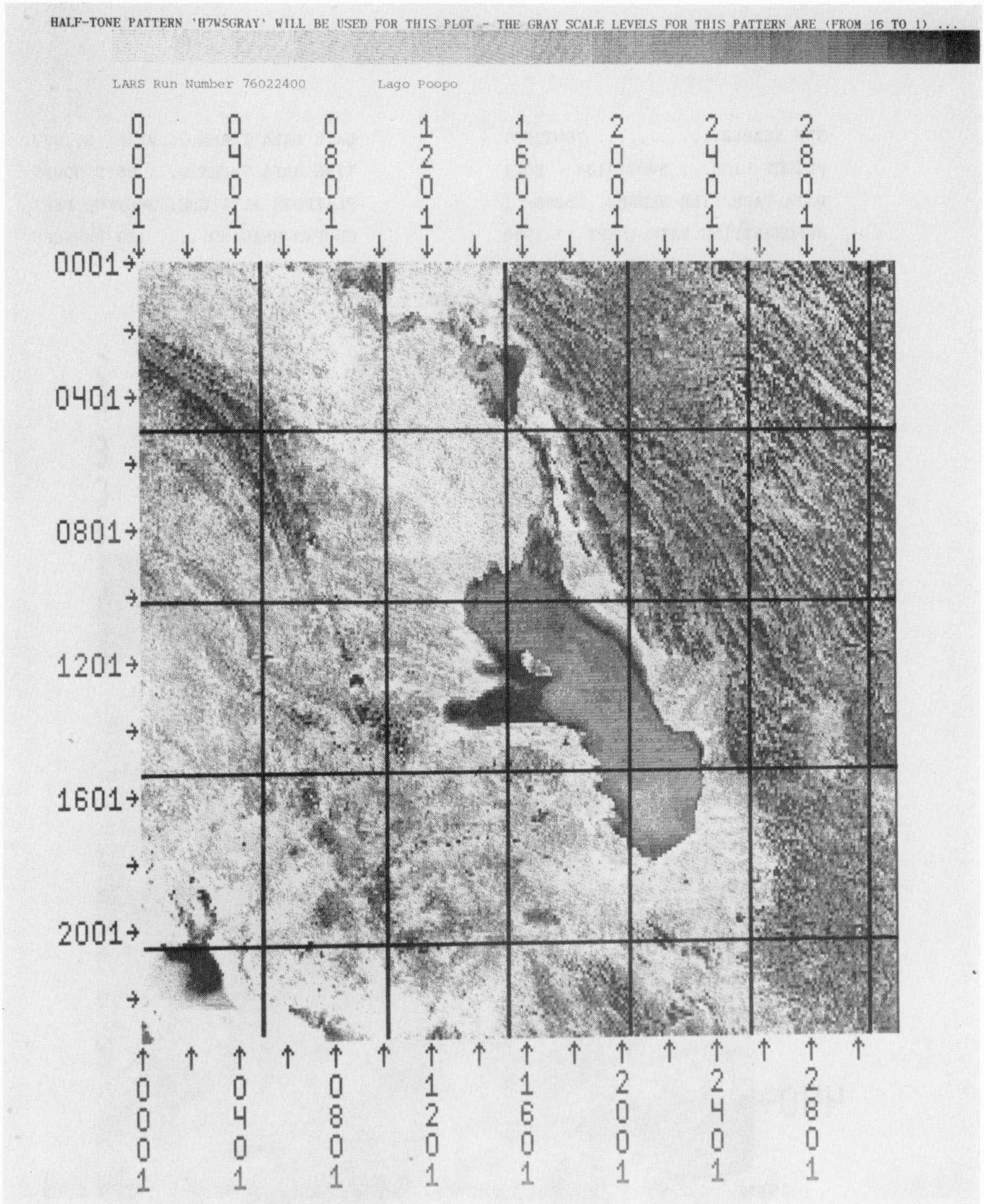

Figure 8. Lago Poopo Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

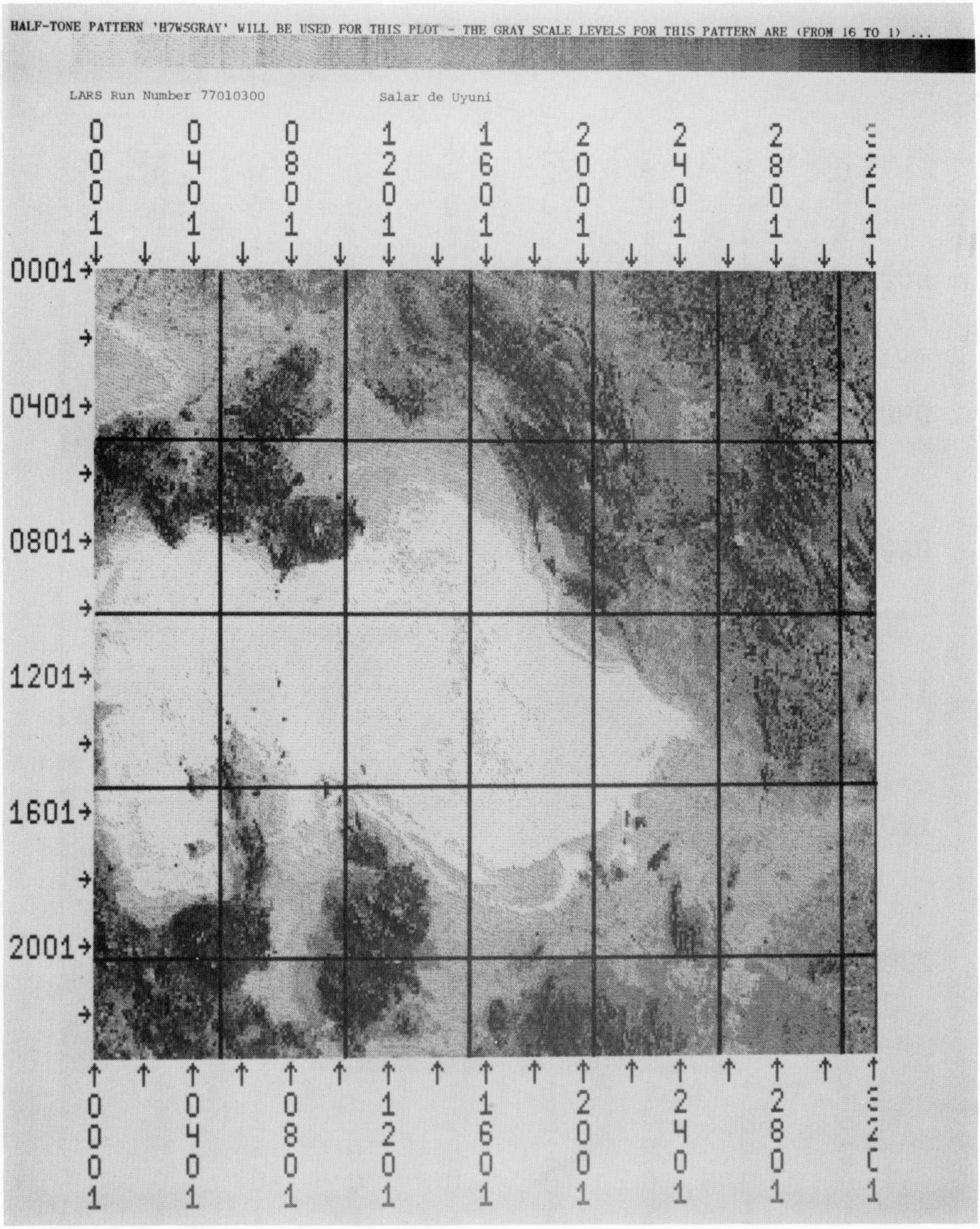

Figure 9. Salar de Uyuni Landsat MSS subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

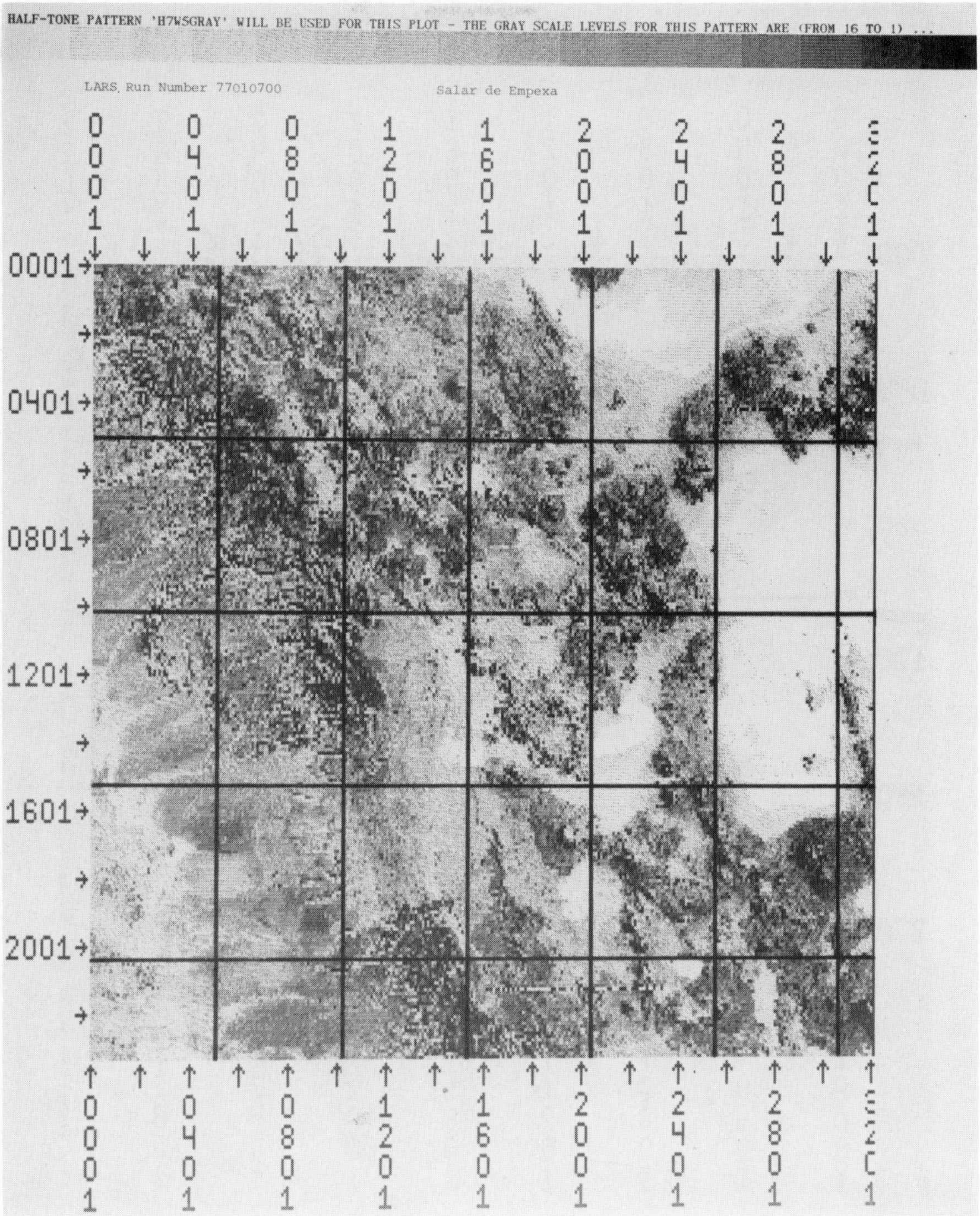

Figure 10. Salar de Empexa Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

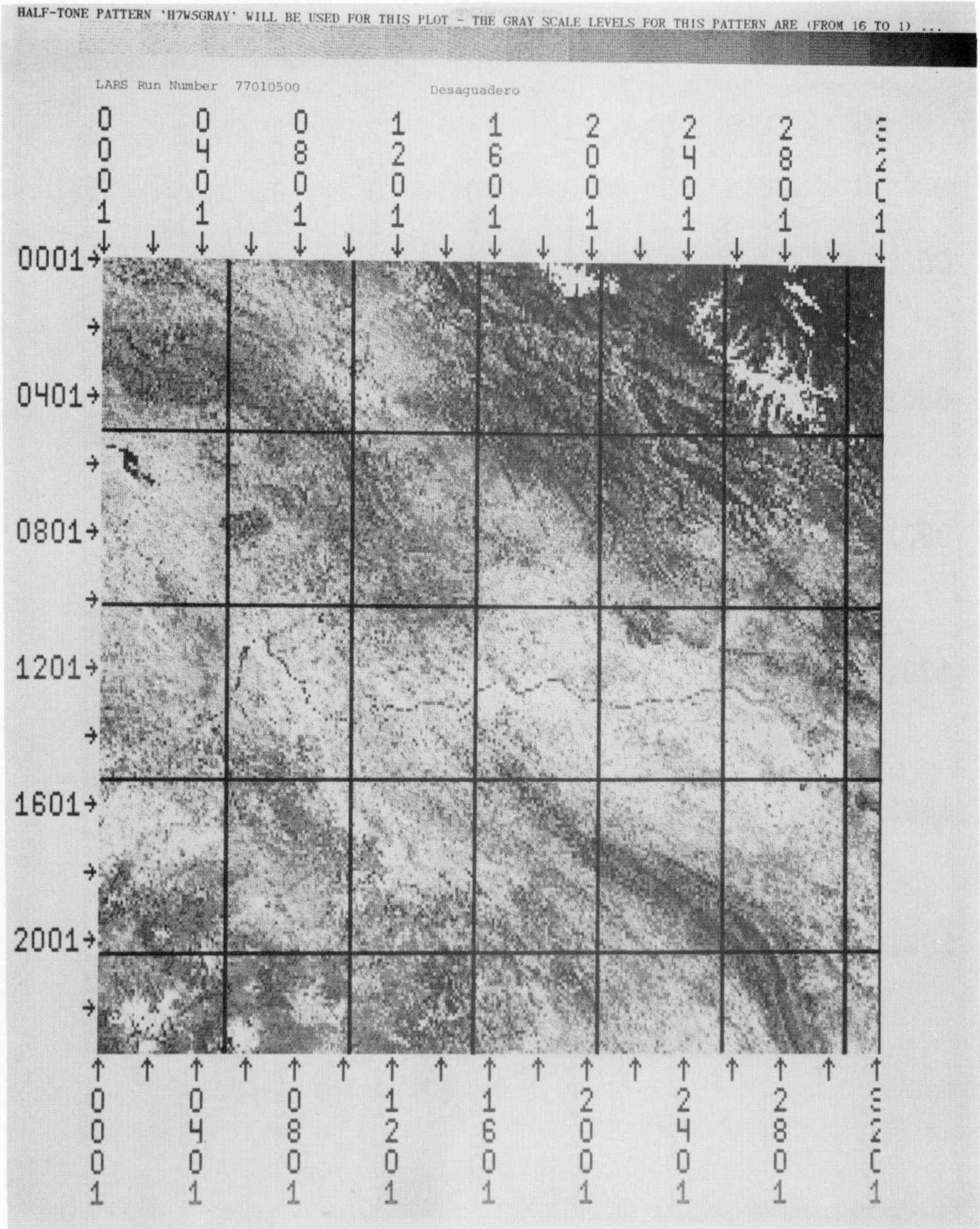

Figure 11. Desaguadero Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

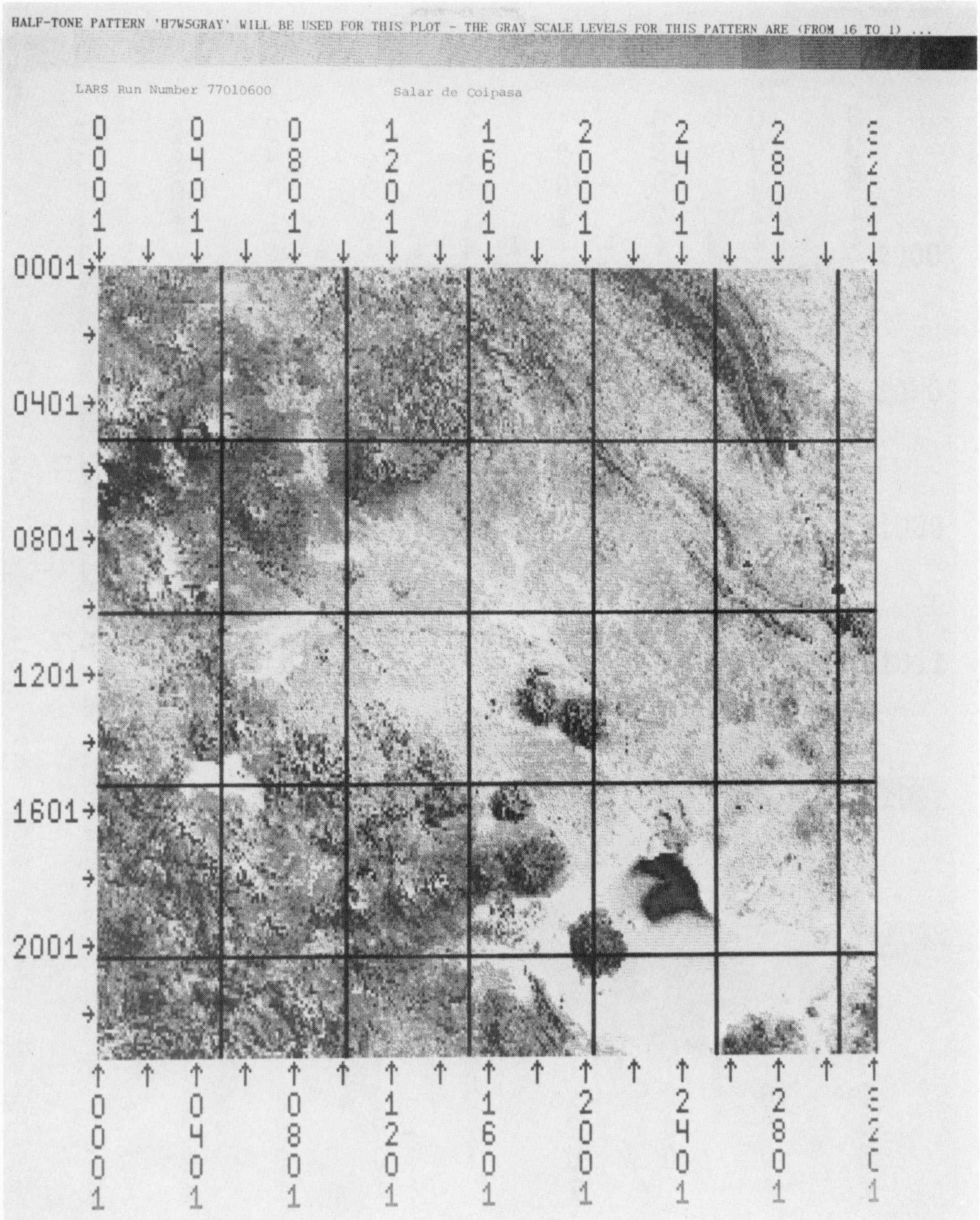

Figure 12. Salar de Coipasa Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

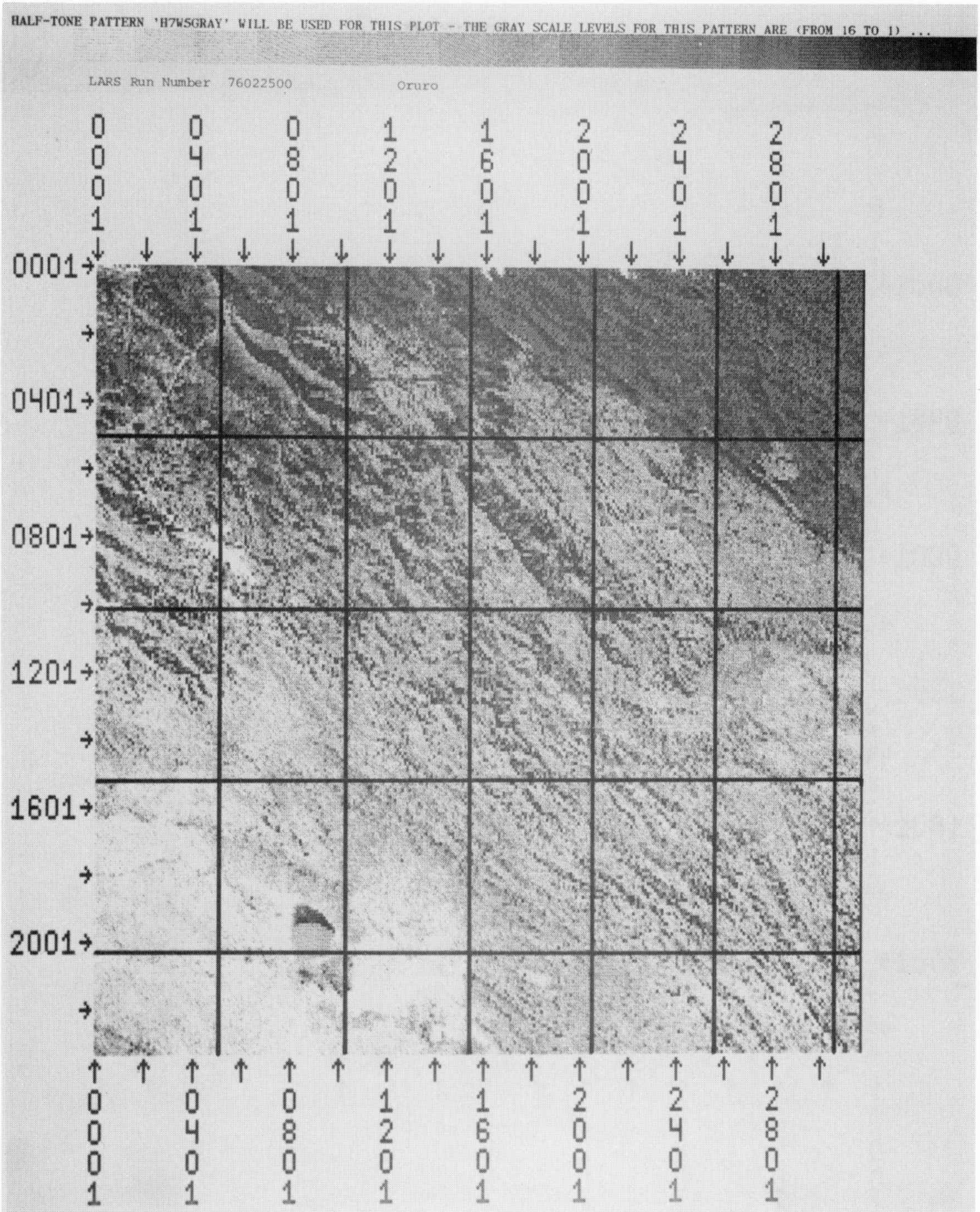

Figure 13. Oruro Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

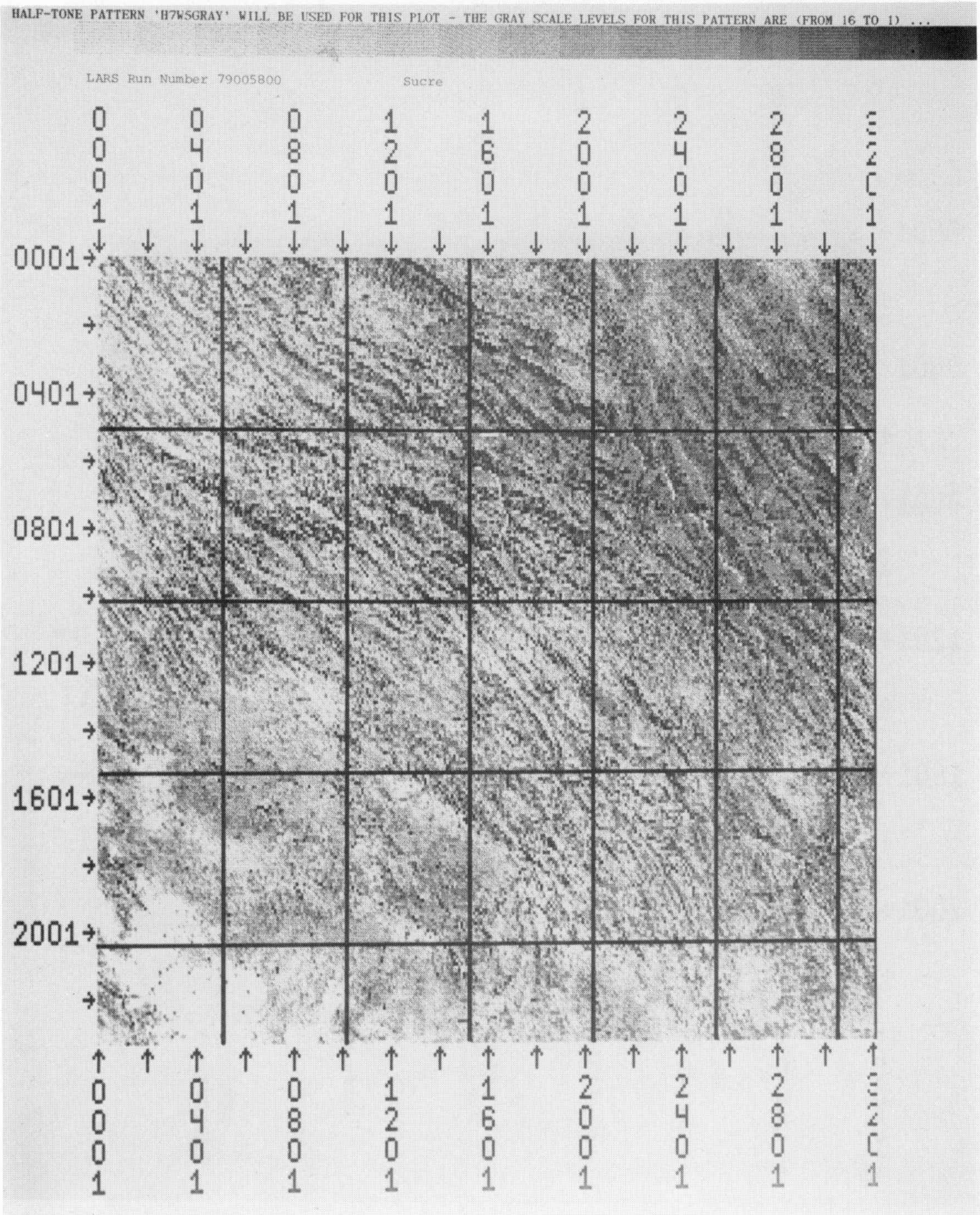

Figure 14. Sucre Landsat MSS scene subdivided into 35 subareas for visual inspection of the data in a COMTAL Vision One/20 image display.

Each of these 980 subscenes had to be reformatted on the IBM 3031 computer, then transferred to the PDP 11/34 minicomputer using a 9600 baud IBM 2780 protocal link, and finally transferred to the COMTAL Vision One/20. In addition to the time taken by this transferring process, during the visual inspection of the imagery the analyst had to locate the exact address of the bad scan lines and problem pixels and record them for subsequent correction.

Control Point Selection on the Landsat Data

As stated in the section entitled SPECIFICATIONS FOR A LANDSAT DIGITAL MOSAIC of the previous Quarterly Progress Report (for the period August 1, 1980-October 31, 1980), in order to create the digital Landsat mosaic of the Oruro Department, Purdue University/LARS had agreed to provide JPL:

1. The seven Landsat MSS frames covering the Oruro Department (see Figure 15) after the corresponding CCT's had been reformatted from the Brazilian INPE format to the LARSYS format, and

2. Approximately 25 ground control points for each of the seven frames.

The ground control points are required to perform the geometric rectification of the Landsat scenes, and to achieve mosaicking of several adjacent frames. Zobrist (1978) has explained that there are two major reasons for incorporating known ground control points in the Landsat mosaicking process:

"a) The Landsat multispectral scanner is not a framing imaging system, so that continuous changes in pointing perspective geometry make it virtually impossible to reconstruct a perfect orthophoto image, and

b) The relative position of points on the earth's surface is precisely known with the result that geodetic control points must be used to warp the projected image from the satellite if any satellite mosaic

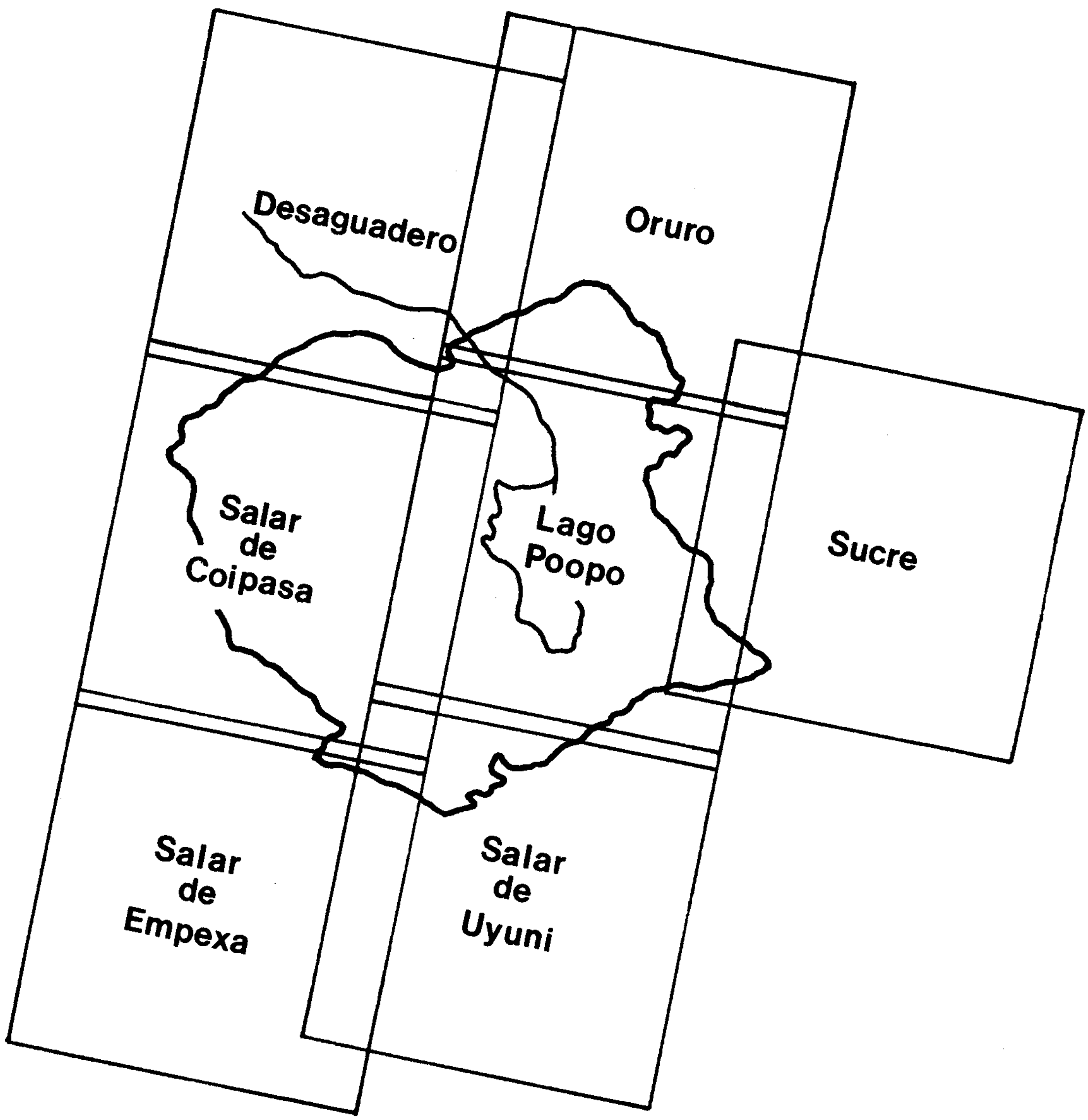

Figure 15. Distribution of the seven Landsat MSS scenes that will be used to create the digital mosaic of the Oruro Department.

is to be expected to conform to the planimetry of existing maps."

The required known ground control points were located on the Landsat imagery using the COMTAL Vision One/20 image display device. The location and identification of these control points was carried out independently by two different analysts during the process of data quality assessment. The selection was based primarily on the following two criteria:

1. The points should be evenly distributed throughout the scene, i.e., a representative sample in the spatial domain, and
2. They should represent readily and reliably identifiable ground features on both the Landsat image and the 1:250,000 topographic map.

Ground control points that would meet both of the above stated criteria were difficult to find because in certain instances several easily identifiable features on both the Landsat images and the topographic maps were located too close to one another and therefore they did not constitute a spatially representative sample. In other instances, easily identifiable features on the Landsat image could not be related to corresponding features on the maps because three 1:250,000 topographic maps (Aiquile SE 20-9, Sucre SE 20-13, and Villa Martin SF 19-3) were not available. Figure 16 shows the distribution of the 1:250,000 topographic sheets with respect to the Oruro Department. Nevertheless, an adequate number of and spatially representative ground control points were selected on the Landsat images on six of the seven available topographic maps. Table 3 shows the list of available 1:250,000 maps over the Oruro Department, and the number of control points selected in each map. Note that no points were selected on the Nevados Payachata SE 19-10 topographic map because only 3 percent of the Oruro Department is included in this topographic sheet.

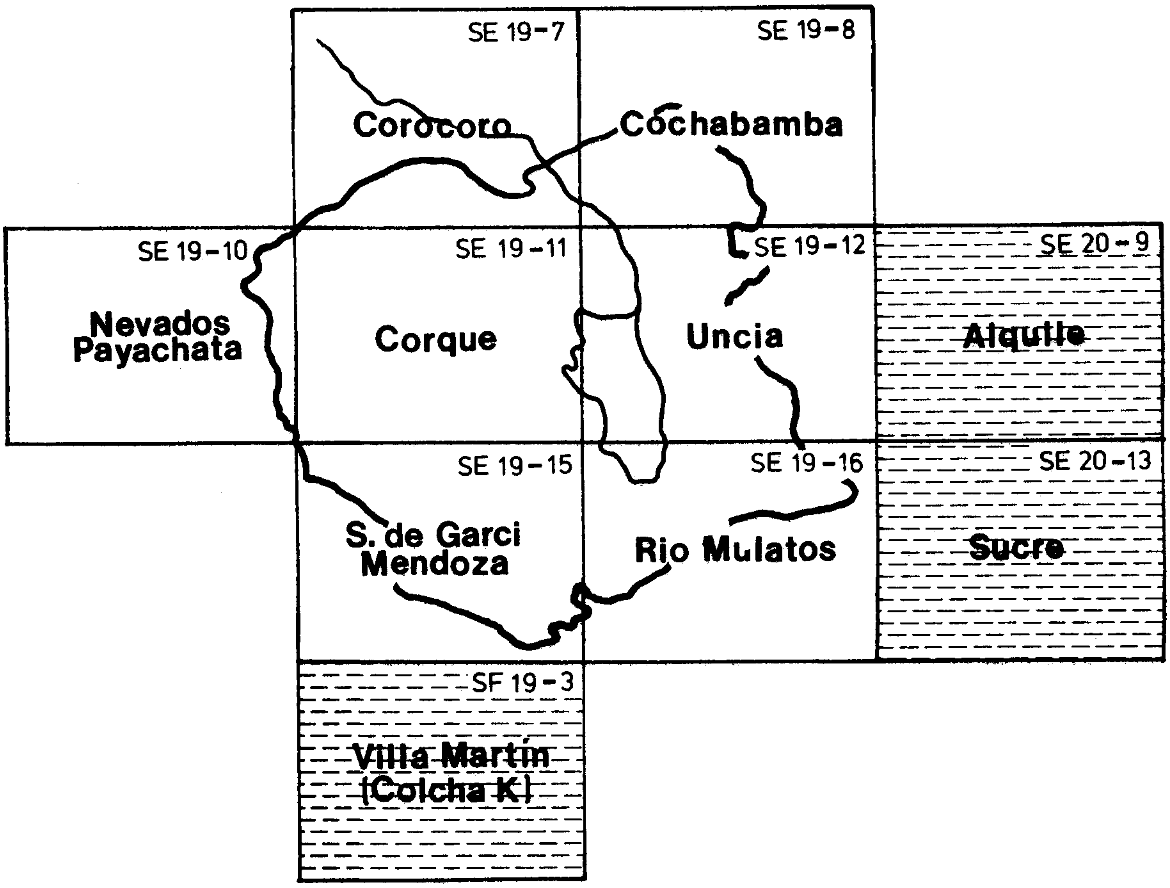

Figure 16. Distribution of the Bolivian IGM topographic maps at a scale of 1:250,000 that cover the Oruro Department.

Table 3. Topographic Maps (1:250,000 scale) Over the Oruro Department, and Number of Selected Control Points on Each Map.

Map Name	Map Series	Number of Control Points
Corocoro	SE 19-7	17
Cochabamba	SE 19-8	16
Corque	SE 19-11	14
Uncia	SE 19-12	11
Salinas de Garci Mendoza	SE 19-15	10
Rio Mulatos	SE 19-16	12
Nevados Payachata	SE 19-10	--

The spatial distribution of the selected ground control points is shown in Figures 17-22 in the next section of this report.

In order to increase the analyst's capability of locating and reliably identifying the ground control features on the Landsat iamgery, the TRUECOLOR function of the COMTAL Vision One/20 was extensively utilized, particularly to enhance rivers and roads. Essentially, the TRUECOLOR function allows the analyst to assign the primary colors blue, green, and red to the Landsat bands 4, 5, and 7 respectively, thus producing a simulated color infrared composite image. On the other hand, it was found that in order to more readily locate and identify mountain peaks, the individual bands either in black and white or in pseudocolor format were more useful, particularly when a "histogram stretching" enhancement procedure was applied to the data in the individual band.

A qualitative evaluation of the accuracy of the ground control points selected on the Landsat images showed that through the image enhancement

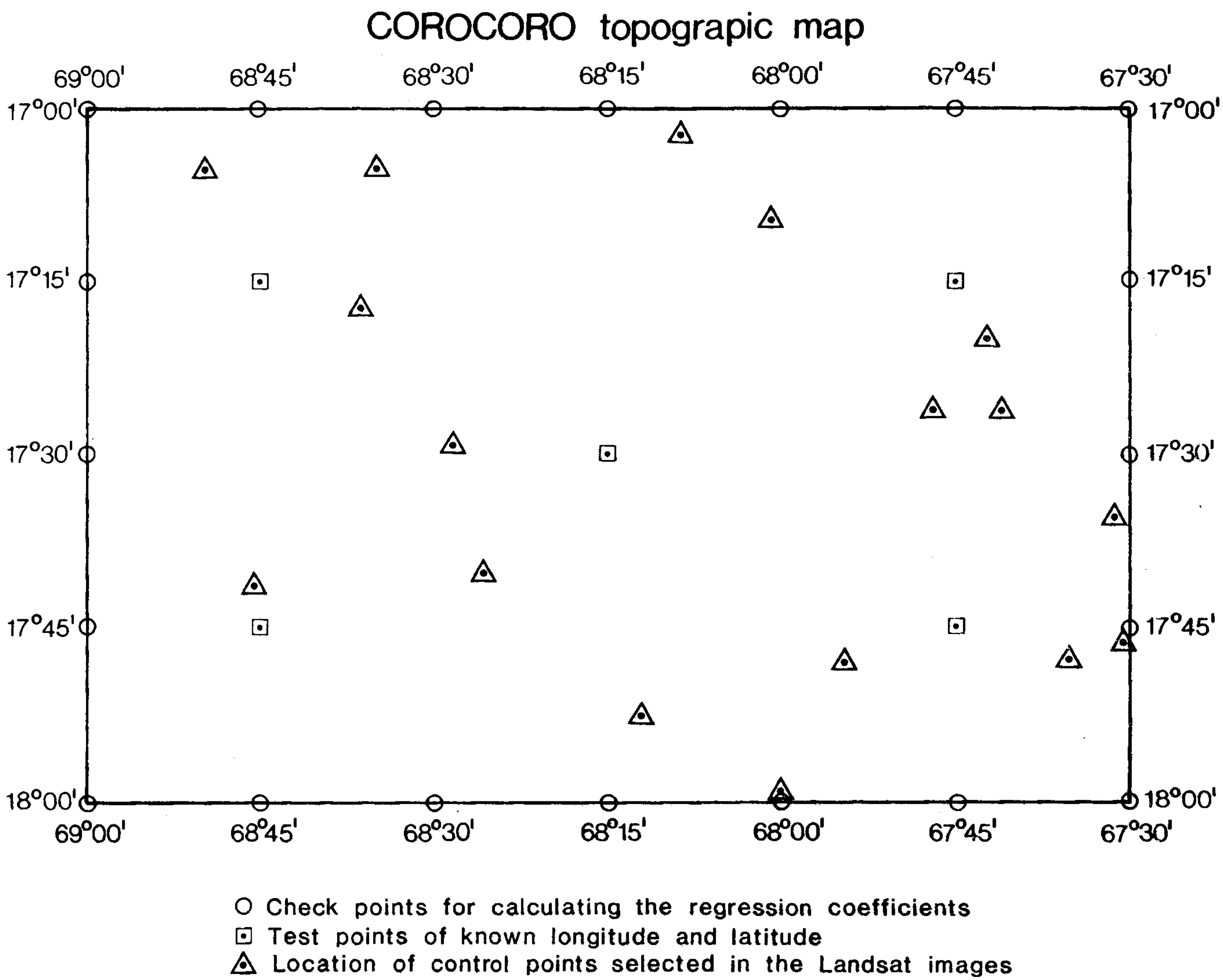

Figure 17. Distribution of check points, test points and ground control points on the Corocoro topographic map.

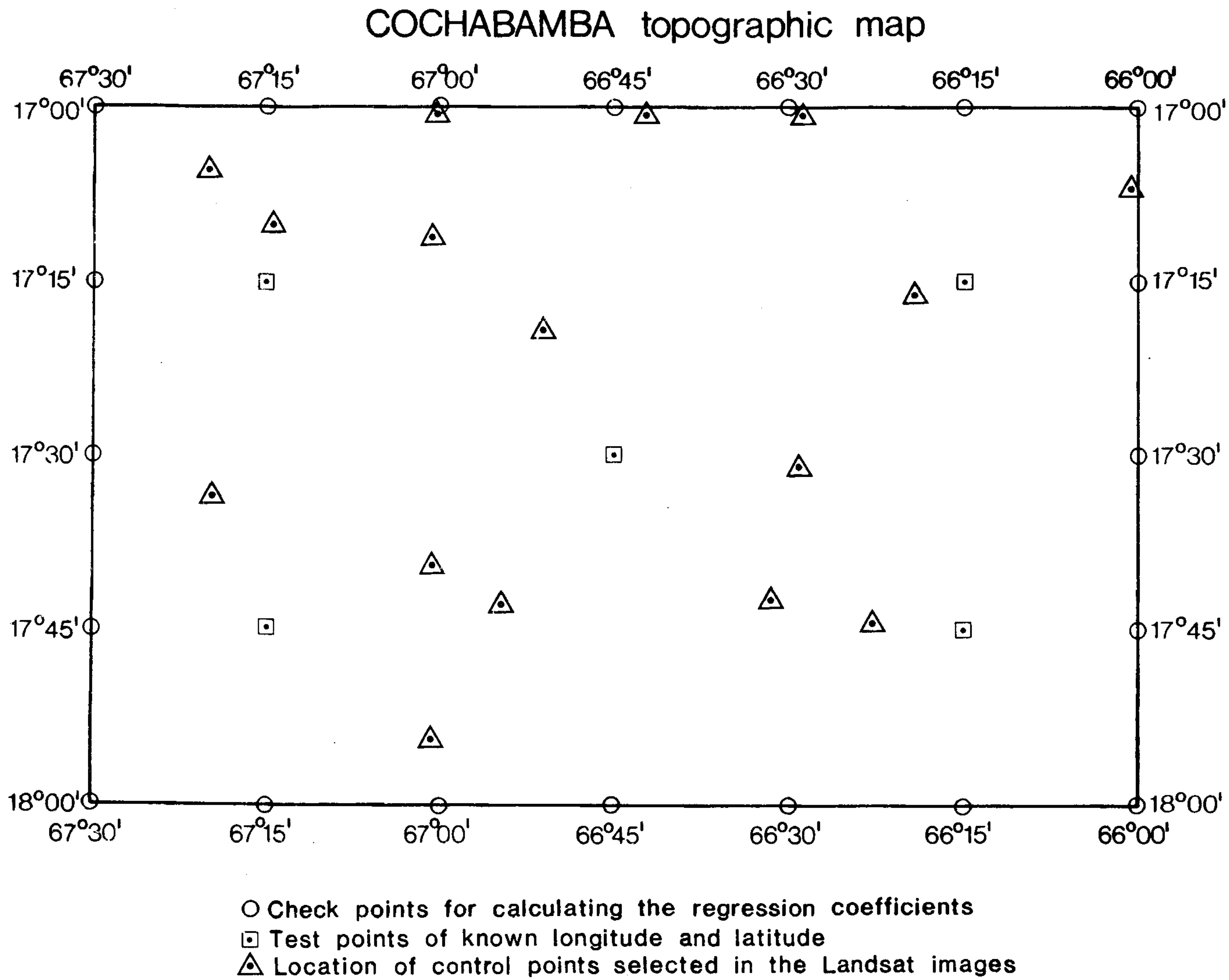

Figure 18. Distribution of check points, test points and ground control points on the Cochabamba topographic map.

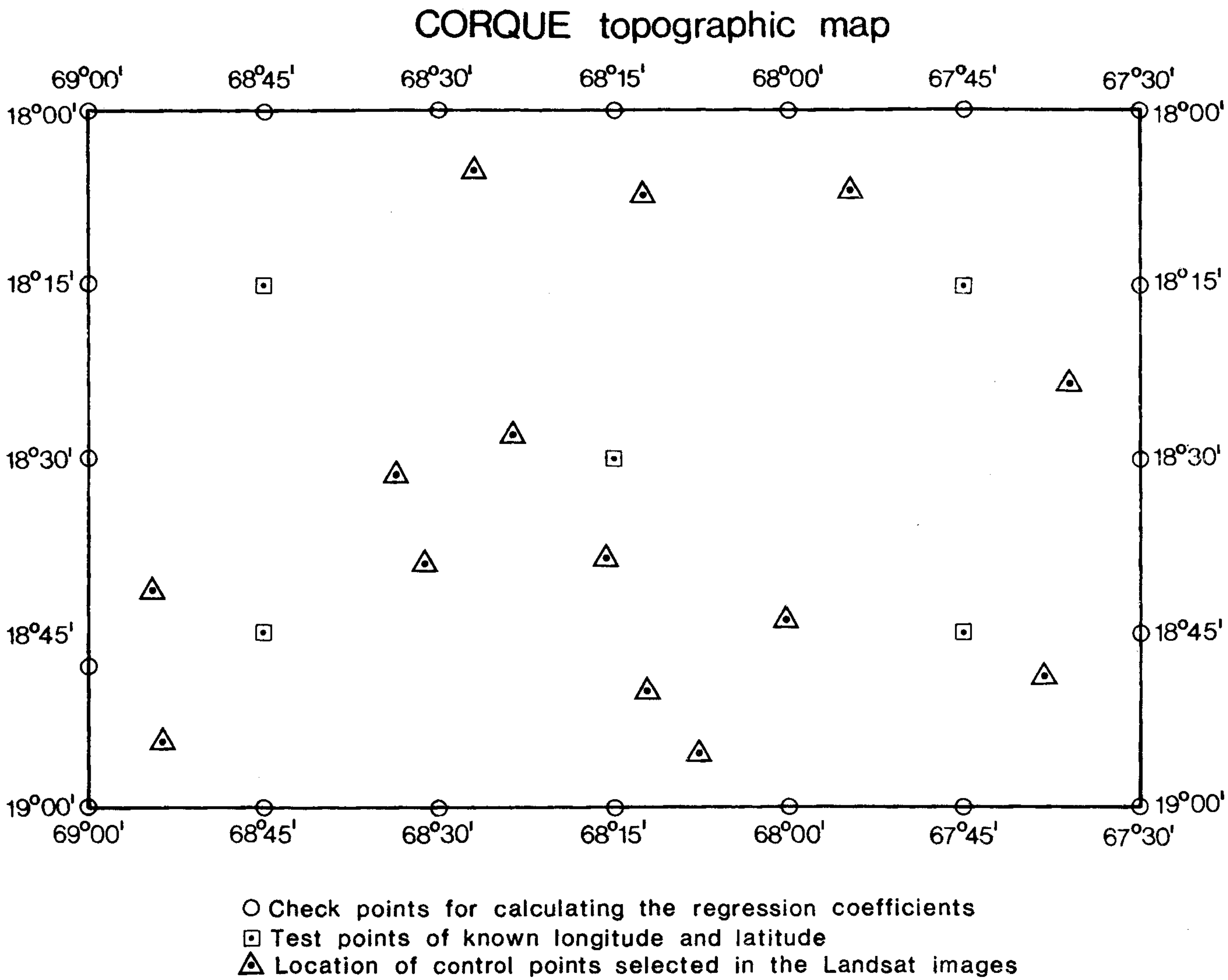

Figure 19. Distribution of check points, test points and ground control points on the Corque topographic map.

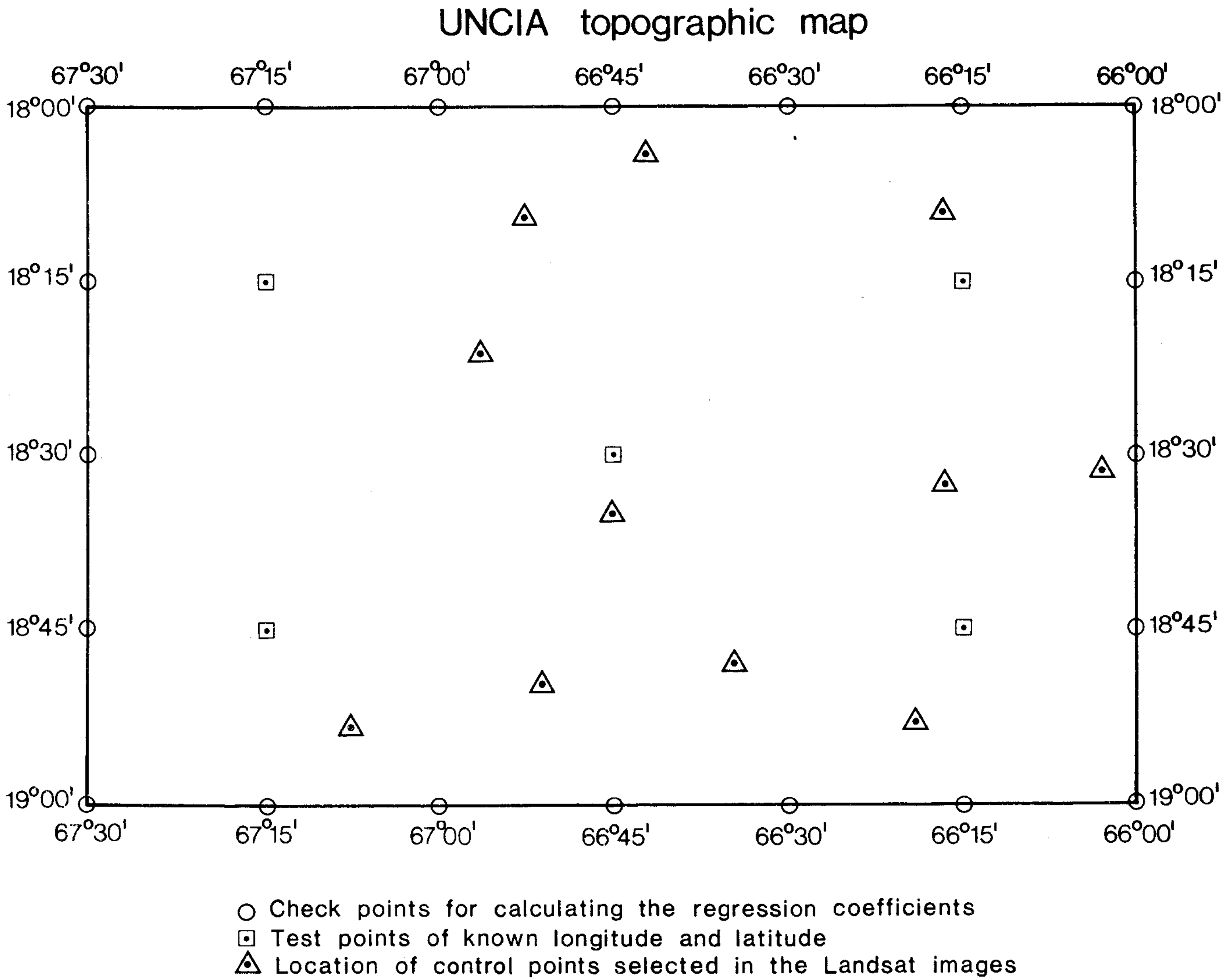

Figure 20. Distribution of check points, test points and ground control points on the Uncia topographic map.

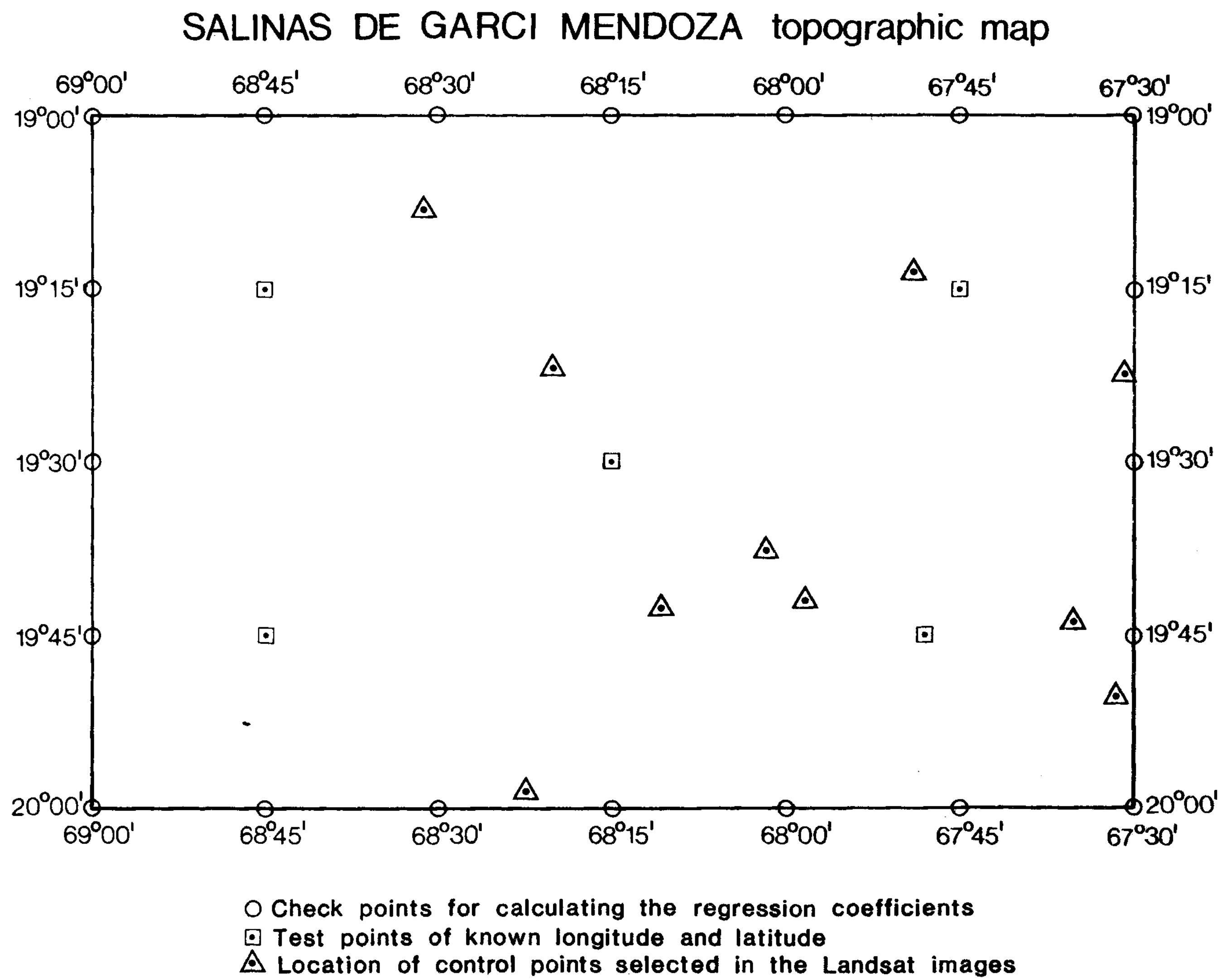

Figure 21. Distribution of check points, test points and ground control points on the Salinas de Garci Mendoza topographic map.

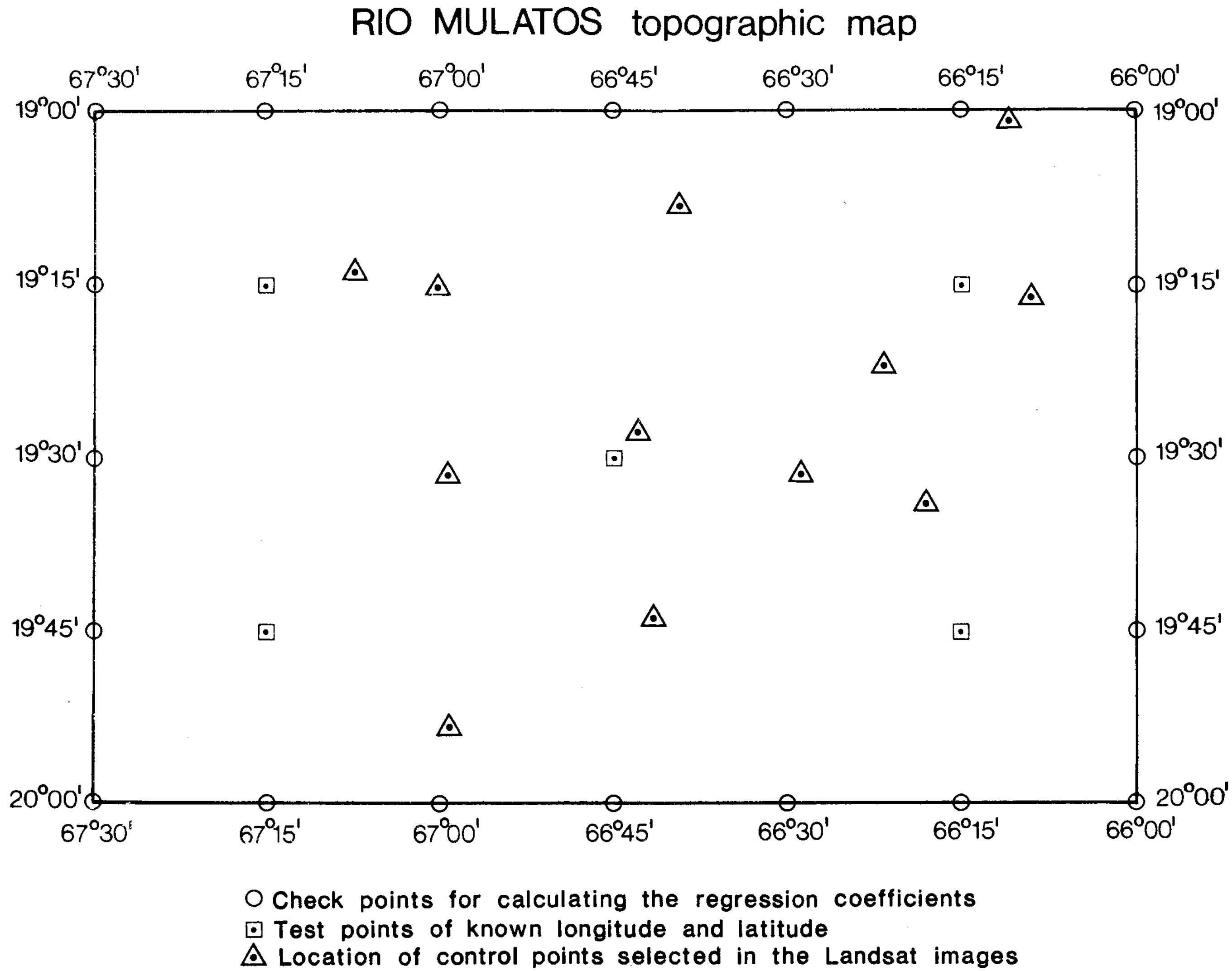

Figure 22. Distribution of check points, test points and ground control points on the Rio Mulatos topographic map.

procedure described above, and enlargement of the image to a level where individual pixels were easily identifiable, the desired pixel address could be located within + or - 1 pixel, i.e., + or - 80 meters. A more rigorous quantitative accuracy evaluation will be performed before the data sets are sent to JPL.

Control Point Location on the 1:250.000 Topographic Maps

To determine the geographic coordinates (Latitude and Longitude) of the ground control points selected on the Landsat imagery, the available 1:250,000 topographic maps were used. First, the selected ground control points were located on the topographic maps, and then utilizing a table digitizer and appropriate software the latitude and longitude of every control point was determined. A brief description of the TALOS table digitizer available at LARS is given in Table 4. Appendix C contains detailed specifications of this table digitizer.

Table 4. Characteristics of the TALOS Table Digitizer Available at LARS.

Model: "The Standard-One"

Resolution: 1000 lines per inch

Active Surface: 44" x 60" (solid surface)

Accuracy: ± 0.01 inch (absolute)

Repetition Rate: Variable 1-100 coordinate pairs per second. Units that have an RS232 programmable interface are limited by the baud rate (9600 baud).

In essence, the TALOS table digitizer operation is based on an electronic servo loop and switching circuit that activates a 1" x 1" area on the digitizing surface. It can resolve any one-inch in both the x and y directions into 1000 divisions of length, usually expressed as lines-per-inch of resolution.

Since the absolute accuracy of this table digitizer is 0.01 of an inch (0.254 mm) the absolute positional addresses on maps of the Oruro Department at a scale of 1:250,000 could be determined with an accuracy of $\pm$ 62.5 meters on the ground, which is a distance equivalent to approximately 2 seconds of longitude or latitude. This accuracy is of the same order of magnitude as the accuracy of $\pm$ 1 Landsat pixel obtained when selecting control points from the COMTAL image display.

A description of the programs developed for the calculation of the latitude and longitude addresses of the ground control points is included in the "Digitization" section of this report.

The actual procedure for obtaining the latitude and longitude coordinates for the ground control points included the following steps:

a) Digitize 20 check points on the map (see circles in Figure 17-22) of known latitude and longitude to be used for the computation of the regression coefficients.

b) Digitize 5 test points on the map (see squares in Figures 17-22) also of known latitude and longitude to test the performance of the regression equation.

c) Digitize the ground control points of unknown latitude and longitude (see triangles in Figures 17-22), and then using the regression equation developed in step "a", calculate their geographic coordinates.

In order to minimize human errors in the process of digitization, three independent table digitizer x and y readings were made by different analysts for steps a, b, and c; then, these three independent readings were averaged. Tables 1 through 30 in Appendix D show the results of the three independent x and y readings, the averaged x and y values, the regression coefficients, and the calculated latitude and longitude coordinates (in degrees and decimals of a degree) for the ground control points selected on the Landsat imagery.

In addition to calculating the geographic coordinates of all the selected ground control points, their corresponding Albers projection addresses were also computed. The origin (address 1, 1) of the Albers projection coordinate system for Bolivia is located in the uppermost lefthand side corner of the quadrant that includes the entire Bolivian territory. Figure 23 shows some reference Albers addresses for the quadrant that includes the whole Bolivian territory and for the quadrant that includes the entire Oruro Department. Note that the Oruro Department quadrangle is composed of 16 smaller (level 2) quadrangles. The Albers addresses for the corners of these 16 quadrangles are shown in Figure 24.

Tables 5 through 11 contain the ground control point information for all the seven Landsat MSS frames covering the Oruro Department. This information together with the corrected Landsat CCT's will be delivered to JPL in early February. According to the agreement with JPL, it should take approximately six months (after the data sets have been delivered) to construct the Landsat digital mosaic for the Oruro Department.

Albers Projection Addresses

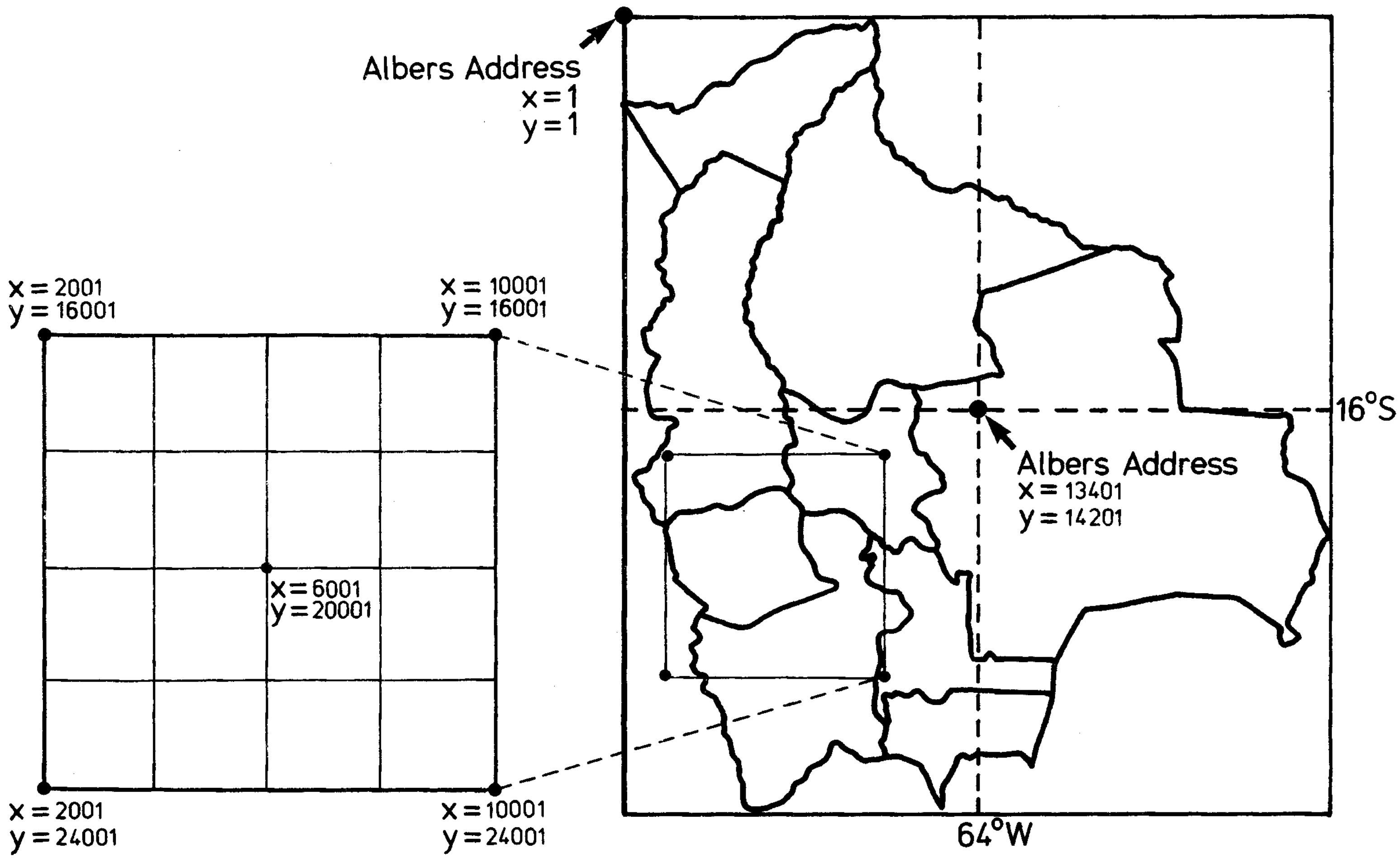

Figure 23. Albers projected map of Bolivia showing some reference Albers address coordinates.

	(2001)	(4001)	(6001)	(8001)	(10001)
(16001)	69.3587951 16.7452515	68.4189675 16.7664013	67.4789599 16.7834855	66.5388108 16.7965031	65.5985582 16.8054531
(18001)	69.383078 17.6465296	68.4389944 17.6677802	67.4947286 17.6849459	66.5503192 17.6980257	65.6058049 17.7070186
(20001)	69.4075819 18.5481233	68.4592037 18.5694808	67.5106408 18.5867331	66.5619323 18.5998788	65.6131176 18.6089171
(22001)	69.4323099 19.4502582	68.4795979 19.4717292	67.5266986 19.4890731	66.5736517 19.5022888	65.6204971 19.5113752
(24001)	69.457265 20.3531653	68.5001795 20.3747563	67.5429039 20.3921973	66.5854788 20.405487	65.6279445 20.4146244

Figure 24. Longitude-latitude and Albers address coordinates for the corners of the 16 (level 2) quadrangles that cover the Oruro Department.

Table 5.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name DESAGUADERO

Image ID (Brazil) 277251-132714 **(NASA)** 295713271

Run Number (LARS) 77010501

N°	COLUMNS, LINES	LONGITUDE, LATITUDE: DEGREES, MIN, SEC	LONGITUDE, LATITUDE: DEGREES, DECIMALS	ADDRESS X, Y
1	188, 883	68°49'31", 17°04'51"	68.825304, 17.080912	3152.94805, 16717.7229
2	637, 829	68°34'59", 17°05'07"	68.583137, 17.085316	3667.3957, 16715.8789
3	1422, 679	68°08'32", 17°02'53"	68.142191, 17.047986	4602.0947, 16613.474
4	1691, 809	68°01'16", 17°09'35"	68.021122, 17.159616	4864.01757, 16856.0306
5	2329, 994	67°42'55", 17°20'38"	67.715189, 17.343973	5520.74382, 17252.8711
6	2918, 559	67°20'06", 17°05'05"	67.335116, 17.084736	6317.63646, 16664.2292
7	3128, 662	67°14'40", 17°10'36"	67.244376, 17.176659	6513.51595, 16865.0828
8	677, 1107	68°36'33", 17°17'00"	68.609119, 17.283201	3621.93401, 17155.969
9	1014, 1349	68°28'41", 17°29'00"	68.478193, 17.483425	3909.21819, 17593.9537
10	2250, 1152	67°47'06", 17°26'46"	67.785085, 17.446009	5376.61556, 17481.8415
11	2437, 1121	67°40'50", 17°26'30"	67.680537, 17.441789	5598.0688, 17468.5115
12	2795, 1299	67°31'30", 17°35'48"	67.524866, 17.596681	5933.87913, 17806.3276
13	3139, 1218	67°19'46", 17°33'47"	67.329519, 17.563058	6346.4768, 17724.9519
14	585, 1699	68°45'44", 17°40'50"	68.762178, 17.680614	3317.39318, 18044.5684
15	1185, 1619	68°26'08", 17°40'47"	68.435608, 17.679846	4008.73968, 18027.6031
16	1678, 1837	68°12'23", 17°52'48"	68.206412, 17.879952	4502.94631, 18464.2658
17	2167,1669	67°55'08", 17°48'05"	67.918836, 17.801497	5107.92486, 18275.434
18	2081, 1951	68°00'53", 17°59'29"	68.014717, 17.991349	4913.15768, 18700.2715
19	2754, 1601	67°35'58", 17°48'06"	67.599403, 17.801689	5783.84885, 18263.6644
20	2895, 1543	67°30'57", 17°46'23"	67.515849, 17.773046	5959.57922, 18197.1269
21	1327, 2172	68°27'20", 18°05'04"	68.455555, 18.084476	3985.69667, 18925.69
22	1778, 2178	68°12'53", 18°07'31"	68.214741, 18.125283	4496.33431, 19005.5761
23	2318, 2097	67°54'49", 18°06'48"	67.913586, 18.113403	5132.02504, 18966.8261

Table 6.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name ORURO

Image ID (Brazil) 176157-131340 (NASA) 540913134

Run Number (LARS) 76022501

		LONGITUDE, LATITUDE		ADDRESS	
N°	COLUMNS, LINES	DEGREES, MIN, SEC	DEGREES, DECIMALS	X	Y
1	1150, 888	67°02'01", 17°00'43"	67.033720, 17.012036	6955.3678,	16493.1831
2	1713, 825	66°43'07", 17°01'08"	66.718749, 17.018920	7624.73407,	16499.2161
3	2121, 769	66°29'19", 17°01'07"	66.488724, 17.018538	8113.41174,	16492.2619
4	3000, 784	66°01'51", 17°06'56"	66.030696, 17.115557	9088.60967,	16696.927
5	656, 1060	67°20'06", 17°05'05"	67.335116, 17.084736	6317.63646,	16664.2292
6	847, 1168	67°14'40", 17°10'36"	67.244376, 17.176659	6513.51595,	16865.0828
7	1214, 1130	67°02'22", 17°10'59"	67.039517, 17.183174	6948.58998,	16872.9761
8	1588, 1277	66°51'34", 17°19'14"	66.859445, 17.320681	7335.01526,	17172.5714
9	2343, 1472	66°28'59", 17°31'33"	66.483129, 17.525917	8138.7111,	17617.5609
10	2537, 1070	66°19'19", 17°16'12"	66.322056, 17.270025	8473.71953,	17046.0337
11	203, 1634	67°40'50", 17°26'30"	67.680537, 17.441789	5598.0688,	17468.5115
12	855, 1727	67°19'46", 17°33'47"	67.329519, 17.563058	6346.4768,	17724.9519
13	537, 1801	67°31'30", 17°35'48"	67.524866, 17.596681	5933.87913,	17806.3276
14	1401, 1792	67°02'57", 17°39'38"	67.049110, 17.660511	6943.7208,	17931.9919
15	1635, 1835	66°54'42", 17°43'17"	66.911607, 17.721427	7236.7875,	18062.9248
16	2340, 1754	66°32'01", 17°43'10"	66.533689, 17.719306	8036.78446,	18047.7662
17	2631, 1742	66°22'52", 17°44'50"	66.381009, 17.747272	8360.72615,	18105.9773
18	493, 2106	67°35'58", 17°48'06"	67.599403, 17.801689	5783.84832,	18263.6645
19	638, 2043	67°30'57", 17°46'23"	67.515849, 17.773046	5959.57922,	18197.1269
20	1381, 2161	67°07'02", 17°54'54"	67.117662, 17.915066	6807.00205,	18498.6551
21	2166, 2272	66°42'36", 18°04'19"	66.709957, 18.071873	7673.78722,	18834.3165
22	2984, 2281	66°16'56", 18°09'12"	66.282098, 18.153454	8579.96458,	19004.3842

Table 7.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name Salar De Coipasa

Image ID (Brazil) 277233-132841 (NASA) 293913284

Run Number (LARS) 77010601

N°	COLUMNS, LINES	LONGITUDE, LATITUDE: DEGREES, MIN, SEC	LONGITUDE, LATITUDE: DEGREES, DECIMALS	ADDRESS X, Y
1	1222, 342	68°27'20", 18°05'04"	68.455555, 18.084476	3985.69667, 18925.69
2	1670, 343	68°12'53", 18°07'31"	68.214741, 18.125283	4496.33431, 19005.5761
3	2208, 261	67°54'49", 18°06'48"	67.913586, 18.113403	5132.02504, 18966.8261
4	183,691	69°03'45", 18°14'15"	69.062500, 18.237500	2711.60533, 19294.2134
5	1228, 975	68°33'46", 18°31'38"	68.562641, 18.527114	3780.93224, 19911.817
6	1501, 874	68°23'56", 18°28'47"	68.398885, 18.479612	4123.92697, 19799.1017
7	2903, 584	67°36'18", 18°23'48"	67.604914, 18.396584	5795.01, 19582.8847
8	637, 1219	68°55'09", 18°38'40"	68.919217, 18.644327	3035.38098, 20188.7022
9	1326,1070	68°31'44", 18°36'03"	68.528891, 18.600814	3855.63197, 20073.6151
10	1797, 1007	68°15'50", 18°35'56"	68.264004, 18.598889	4413.75636, 20057.5689
11	2006, 1336	68°12'36", 18°50'57"	68.209915, 18.849235	4538.95573, 20610.0798
12	2251, 1141	68°02'40", 18°43'59"	68.044582, 18.733142	4881.94922, 20345.9034
13	2181, 1458	68°07'58", 18°55'32"	68.132689, 18.925479	4704.84951, 20775.7819
14	3009, 1161	67°38'52", 18°48'49"	67.647819, 18.813545	5720.67588, 20508.6731
15	811, 1640	68°54'00", 18°57'35"	68.899952, 18.959662	3092.40339, 20886.5158
16	1571, 1794	68°31'23", 19°08'01"	68.523137, 19.133619	3893.391, 21254.014
17	2881, 1761	67°49'05", 19°13'19"	67.818009, 19.221923	5378.97022, 21419.9873
18	1998, 2080	68°20'49", 19°21'58"	68.347022, 19.366087	4274.27433, 21761.1165

Table 8.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name LAGO POOPO

Image ID (Brazil) 176157-131405 (NASA) 540913140

Run Number (LARS) 76022401

N°	COLUMNS, LINES	LONGITUDE, LATITUDE DEGREES, MIN, SEC	LONGITUDE, LATITUDE DEGREES, DECIMALS	ADDRESS X, Y
1	488, 64	67°35'58", 17°48'06"	67.599403, 17.801689	5783.84885, 18263.6644
2	630, 10	67°30'57", 17°46'23"	67.515849, 17.773046	5959.57922, 18197.1269
3	1393, 109	67°07'02", 17°54'54"	67.117262, 17.915066	6807.84802, 18498.6425
4	1922, 384	66°52'40", 18°09'29"	66.877902, 18.158041	7321.51385, 19030.1397
5	2178, 220	66°42'36", 18°04'19"	66.709957, 18.071873	7673.78722, 18834.3167
6	2984, 240	66°16'56", 18°09'12"	66.282098, 18.153454	8579.96458, 19004.3842
7	64, 570	67°54'49", 18°06'48"	67.913586, 18.113403	5132.02504, 18966.8261
8	745, 885	67°36'18", 18°23'48"	67.604914, 18.396584	5795.01, 19582.8847
9	1882, 683	66°56'51", 18°21'29"	66.947503, 18.358143	7180.76972, 19475.8517
10	2329, 939	66°45'02", 18°35'05"	66.750583, 18.584690	7602.94287, 19972.3998
11	3142, 781	66°17'17", 18°32'46"	66.287928, 18.546133	8577.20894, 19875.1348
12	110, 1447	68°02'40", 18°43'59"	68.044582, 18.733142	4881.94922, 20345.9034
13	850, 1461	67°38'52", 18°48'49"	67.647819, 18.813545	5720.67588, 20508.6731
14	1780, 1448	67°08'14", 18°53'25"	67.137226, 18.890341	6793.18206, 20661.3683
15	2251, 1310	66°51'22", 18°50'11"	66.856178, 18.836490	7388.01974, 20533.5131
16	2723, 1206	66°35'06", 18°48'26"	66.584875, 18.807267	7958.34716, 20461.2867
17	38, 1728	68°07'58", 18°55'32"	68.132689, 18.925479	4704.84951, 20775.7819
18	1950, 1919	67°07'37", 19°14'13"	67.126915, 19.237050	6831.41178, 21429.3031
19	2157, 1918	67°00'48", 19°15'24"	67.013298, 19.256775	7070.734, 21469.4875
20	2735, 1674	69°39'30", 19°08'17"	66.658371, 19.137930	7812.95337, 21196.0161
21	732, 2057	67°49'05", 19°13'19"	67.818009, 19.221923	5378.97022, 21419.9873
22	1338, 2197	67°30'38", 19°22'46"	67.510437, 19.379514	6031.02922, 21757.7419
23	2413, 2257	66°56'06", 19°31'13"	66.934864, 19.520386	7243.72108, 22051.1034
24	2749, 2129	66°43'11", 19°27'40"	66.719808, 19.461215	7693.16611, 21913.9126

Table 9.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name SUCRE

Image ID (Brazil) 279167-133408 (NASA) 660113340

Run Number (LARS) 79005801

N°	COLUMNS, LINES	LONGITUDE, LATITUDE DEGREES, MIN, SEC	LONGITUDE, LATITUDE DEGREES, DECIMALS	ADDRESS X, Y
1	302, 373	66°16'56", 18°09'12"	66.282098, 18.153454	8579.96458, 19004.3842
2	1683, 321	65°32'23", 18°14'16"	65.539722, 18.237778	10149.6138, 19176.9808
3	2161, 178	65°16'01", 18°10'48"	65.266944, 18.180000	10724.8443, 19044.9845
4	2671, 26	64°57'41", 18°07'04"	64.961389, 18.117778	11369.6237, 18903.5567
5	479, 914	66°17'17", 18°32'46"	66.287928, 18.546133	8577.20894, 19875.1348
6	878, 828	66°03'35", 18°31'16"	66.059809, 18.521203	9051.60449, 19814.8498
7	1312, 547	65°46'46", 18°21'53"	65.779444, 18.364722	9645.81503, 19462.478
8	1788, 644	65°32'14", 18°28'28"	65.537222, 18.474444	10158.7642, 19701.6742
9	1557, 796	65°41'32", 18°33'38"	65.692222, 18.560556	9833.40289, 19895.1133
10	2462, 713	65°11'30", 18°34'48"	65.191667, 18.580000	10888.9217, 19930.9161
11	58, 1344	66°35'06", 18°48'26"	66.584815, 18.807267	7958.34716, 20461.2867
12	567, 1392	66°19'33", 18°53'11"	66.325719, 18.886301	8505.95133, 20630.0247
13	1160, 1221	65°55'11", 18°49'16"	65.919722, 18.821111	9359.11411, 20476.8326
14	1586, 1077	65°43'18", 18°44'52"	65.721667, 18.747778	9774.75662, 20310.6439
15	1839, 1278	65°37'23", 18°55'21"	65.623056, 18.922500	9985.46732, 20696.2401
16	2849, 1222	65°04'24", 18°58'05"	65.073333, 18.968056	11142.8027, 20789.7209
17	78, 1815	66°39'30", 19°08'17"	66.658371, 19.137930	7812.95337, 21196.0161
18	884, 1585	66°11'18", 19°03'04"	66.188414 19.051163	8798.77, 20992.2562
19	1073, 1949	66°09'15", 19°19'11"	66.154277, 19.319813	8876.71212, 21586.7747
20	1710, 1685	65°45'54", 19°11'31"	65.765000, 19.191944	9691.82746, 21295.7698
21	2140, 1963	65°34'58", 19°25'20"	65.582778, 19.422222	10078.6374, 21802.8945
22	2631, 1669	65°16'01", 19°15'31"	65.266944, 19.258611	10739.382, 21435.8737
23	96, 2275	66°43'11", 19°27'40"	66.719808, 19.461215	7693.16611, 21913.9126
24	720, 2051	66°21'36", 19°21'38"	66.360129, 19.360461	8445.43141, 21681.5112

Table 10.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name Salar de Empexa

Image ID (Brazil) 277233-132906 (NASA) 293913290

Run Number (LARS) 77010701

Nº	COLUMNS, LINES	LONGITUDE, LATITUDE DEGREES, MIN, SEC	LONGITUDE, LATITUDE DEGREES, DECIMALS	ADDRESS X, Y
1	2002, 21	68°20'49", 19°21'58"	68.347022, 19.366087	4274.27433, 21761.1165
2	2433, 473	68°11'09", 19°42'42"	68.185866, 19.711564	4627.95348, 22519.3225
3	2672, 317	68°01'54", 19°37'26"	68.031568, 19.623915	4947.54549, 22318.8497
4	2818, 411	67°58'13", 19°42'10"	67.970326, 19.702912	5079.276825, 22491.3219
5	2209, 871	68°22'30", 19°58'18"	68.374993, 19.971754	4243.7212, 23103.523
6	1998, 1151	68°32'10", 20°09'14"	68.536111, 20.153889	3915.31592, 23513.8739
7	1969, 1421	68°35'51", 20°20'28"	68.597500, 20.341111	3796.10605, 23930.9939
8	2421, 1963	68°26'44", 20°45'39"	68.445556, 20.760833	4133.304, 24852.5748
9	2954, 1727	68°07'21", 20°38'28"	68.122500, 20.641111	4801.45117, 24573.9339
10	2504, 2165	68°26'11", 20°54'51"	68.436389, 20.914167	4159.63171, 25191.2284
11	2908, 2021	68°11'47", 20°50'47"	68.196389, 20.846389	4656.48351, 25031.0026

Table 11.

GROUND CONTROL POINTS
ORURO DEPARTMENT

Image Name Salar de Uyuni

Image ID (Brazil) 277232-132326 (NASA) 293813232

Run Number (LARS) 77010301

		LONGITUDE, LATITUDE		ADDRESS
N°	COLUMNS, LINES	DEGREES, MIN, SEC	DEGREES, DECIMALS	X . Y
1	929, 120	67°30'38", 19°22'46"	67.510437, 19.379514	6031.02922, 21757.7419
2	1046, 303	67°29'05", 19°31'22"	67.484828, 19.522885	6090.10057, 22074.4126
3	2025, 183	66°56'06", 19°31'13"	66.934864, 19.520386	7243.72108, 22051.1034
4	2364, 58	66°43'11", 19°27'40"	66.719808, 19.461215	7693.16611, 21913.9126
5	2544, 423	66°41'53", 19°43'59"	66.697981, 19.733047	7746.76619, 22515.3848
6	3181, 100	66°18'18", 19°33'38"	66.304975, 19.560564	8566.13731, 22123.4828
7	102, 573	68°01'54", 19°37'26"	68.031568, 19.623915	4947.54549, 22318.8497
8	244, 661	67°58'13", 19°42'10"	67.970326, 19.702912	5079.27682, 22491.3219
9	965, 615	67°34'57", 19°43'50"	67.582473, 19.730601	5893.17881, 22537.9042
10	1100, 752	67°32'12", 19°50'25"	67.536614, 19.840253	5993.39809, 22779.064
11	2091, 704	66°59'20", 19°53'30"	66.988837, 19.891625	7142.28828, 22874.8455
12	2908, 917	66°35'37", 20°06'42"	66.593611, 20.111667	7975.9211, 23350.9136
13	2604, 962	66°45'58", 20°07'00"	66.766111, 20.116667	7615.26885, 23366.6223
14	2688, 1307	66°46'46", 20°21'58"	66.779444, 20.366111	7594.74738, 23919.0811
15	416, 1980	68°07'21", 20°38'28"	68.122500, 20.641111	4801.45117, 24573.9339
16	1123, 1728	67°41'46", 20°31'45"	67.696111, 20.529167	5686.40818, 24309.6075
17	1812, 1970	67°22'10", 20°45'30"	67.369444, 20.758333	6376.36942, 24804.9744
18	2359, 1698	67°01'32", 20°36'53"	67.025556, 20.614722	7088.64235, 24476.3073
19	2377, 1987	67°04'02", 20°49'10"	67.067222, 20.819444	7008.38512, 24930.3998
20	375, 2275	68°11'47", 20°50'47"	68.196389, 20.846389	4656.48351, 25031.0026

SPECIFICATION OF THE DATA BASE ELEMENTS

Definitions and Conventions

The layers or channels in a geographic information system are referred to as "elements" of the data base. Sometimes these elements are also called "geocoded planes." Table 12 shows a list of the "elements" that the ERTS/GEOBOL Program has selected for input into the Oruro Department data base.

The different features (units) within a data base element are known as "classes", for example the different lithologic units in a geologic map are the different "classes" of the geologic element of the data base. In a digital data base it is possible to store a maximum of 256 (2^8) different classes for each element. In other words, there is a maximum of 256 digital codes (fill characters) ranging from zero to 255 that can be used to represent different classes within a data base element.

For the Bolivian geographic information system, assignment of the 256 available numerical codes will be done according to the following rules (convention):

- The Ø (zero) code will be used to represent a class for which there is no available data at the present time. For example, an area within the Bolivian territory where a soil survey has not been conducted yet will be represented by the numerical code Ø (zero) until the soils information for that area is available.
- The 255 code will be used to represent a class for which there will never be data. For example, areas outside of the Bolivian territory will be represented by the numerical value (code) 255.

Table 12. List of Elements (Layers or Channels) Recommended by ERTS/GEOBOL for Input into The Oruro Department Geographic Information System.

	ELEMENT (Layer or Channel)	AVAILABLE DATA (Scale)
1.	Landsat MSS 4	7 Landsat CCT's
2.	Landsat MSS 5	7 Landsat CCT's
3.	Landsat MSS 6	7 Landsat CCT's
4.	Landsat MSS 7	7 Landsat CCT's
5.	Department, Province and Canton Boundaries	1 Political boundary map (1:500,000)
6.	Elevation	ERTS/GEOBOL will provide simplified topographic maps (1:250,000 scale)
7.	Slope	Will be derived from elevation data
8.	Aspect (azimuth)	Will be derived from elevation data
9.	Land cover/Land use	7 Land use maps (1:250,000)
10.	Soils	7 Soils maps (1:250,000)
11.	Hydrology (Watersheds, permeability, etc.)	7 Hydrological maps (1:250,000)
12.	Geology	7 Geological/Lithologic maps (1:250,000)
13.	Geomorphology	7 Geomorphologic maps (1:250,000)
14.	Climatology	ERTS/GEOBOL will provide maps from SYMAP
15.	Socio-Economic Space	ERTS/GEOBOL will provide census data

- The numerical codes 1 - 254 may be used to represent any one of the different classes within a given element of a digital data base.

In addition to these definitions, a glossary of terms regarding geographic information systems is included in Appendix E of this report (Tessar and Caron, 1980).

Coding of the Political Division Element

Bolivia is divided into 9 Departments (States). Each Department is divided into a number of Provinces, and each Province is further subdivided into a number of Cantones. The names and numerical codes of each of the Departments and Provinces of Bolivia are given in Table 13. The codes shown in this table were defined by the Bolivian National Statistics Institute (INE). For example, the code for the Oruro Department is "4", and the code for the Atahuallpa Province within the Oruro Department is "51". The Bolivian ERTS/GEOBOL Program also provided LARS with the codes for all the Cantones within each one of the 10 provinces in the Oruro Department. Figure 25 shows the location of all the 99 provinces of Bolivia.

Table 14 shows the "fill character" information (digital codes) for all the political subdivisions within the Oruro Department and for the adjacent Departments and Countries. This table also contains information regarding the Level of the Political Division data base and the name and number of the corresponding quadrant. More detailed explanations about coding classes within elements of the Oruro Department data base will be provided in the next report corresponding to the time period, February 1, 1981 - April 30, 1981. Since the class code assignments should be done by the Bolivian counterpart in conjunction with the system designers of LARS, one of the responsibilities of the Bolivian experts (Visiting Scientists) that are expected to arrive at

Table 13. Names and Codes for the Departments and Provinces of Bolivia.

Department Codes

Code		Code		Code	
1	CHUQUISACA	2	LA PAZ	3	COCHABAMBA
4	ORURO	5	POTOSI	6	TARIJA
7	SANTA CRUZ	8	BENI	9	PANDO

(1) DEPARTAMENTO DE CHUQUISACA

Code	Province
01	Oropeza
02	Azurduy
03	Zudañez
04	Tomina
05	Hernando Siles
06	Yamparaez
07	Nor Cinti
08	Belisario Boeto
09	Sud Cinti
10	Luis Calvo

(2) DEPARTAMENTO DE LA PAZ

Code	Province
11	Murillo
12	Omasuyos
13	Pacajes
14	Camacho
15	Muñecas
16	Larecaja
17	Franz Tamayo
18	Ingavi
19	Loayza
20	Inquisivi
21	Sud Yungas
22	Los Andes
23	Aroma
24	Nor Yungas
25	Abel Iturralde
26	Bautista Saavedra
27	Manco Kapac
28	Gualberto Villarroel

(3) DEPARTAMENTO DE COCHABAMBA

Code	Province
29	Cercado
30	Campero
31	Ayopaya
32	Esteban Arce
33	Arani
34	Arque
35	Capinota
36	Jordan
37	Quillacollo
38	Chapare
39	Tapacari
40	Carrasco
41	Mizque
42	Punata

(4) DEPARTAMENTO DE ORURO

Code	Province
43	Cercado
44	Avaroa
45	Carangas
46	Sajama
47	Litoral
48	Poopo
49	Pantaleon Dalence
50	Ladislao Cabrera
51	Atahuallpa
52	Saucari

Table 13. (Continued)

Department Codes

Code		Code		Code	
1	CHUQUISACA	2	LA PAZ	3	COCHABAMBA
4	ORURO	5	POTOSI	6	TARIJA
7	SANTA CRUZ	8	BENI	9	PANDO

(5) DEPARTAMENTO DE POTOSI

Code	Province
53	Frias
54	Bustillos
55	Cornelio Saavedra
56	Chayanta
57	Charcas
58	Nor Chichas
59	Alonso de Ibañez
60	Sud Chichas
61	Nor Lipez
62	Sud Lipez
63	Linares
64	Quijarro
65	Gral. Bilbao
66	Daniel Campos
67	Modesto Omiste

(6) DEPARTAMENTO DE TARIJA

Code	Province
68	Cercado
69	Arce
70	Gran Chaco
71	Aviléz
72	Mendez
73	O'Connor

(7) DEPARTAMENTO DE SANTA CRUZ

Code	Province
74	Andrés Ibañez
75	Warnes
76	Velasco
77	Ichilo
78	Chiquitos
79	Sarah
80	Cordillera
81	Vallegrande
82	Florida
83	Obispo Santiesteban
84	Nuflo de Chavez
85	Angel Sandoval
86	Manuel Maria Caballero

(8) DEPARTAMENTO DE BENJI

Code	Province
87	Cercado
88	Vaca Diez
89	Gral. Ballivian
90	Yacuma
91	Moxos
92	Marbán
93	Mamoré
94	Itenez

(9) DEPARTAMENTO DE PANDO

Code	Province
95	Nicolas Suárez
96	Manuripi
97	Madre de Dios
98	Abuná
99	Gral. F. Román

MAPA INDICE DE DEPARTAMENTOS Y PROVINCIAS

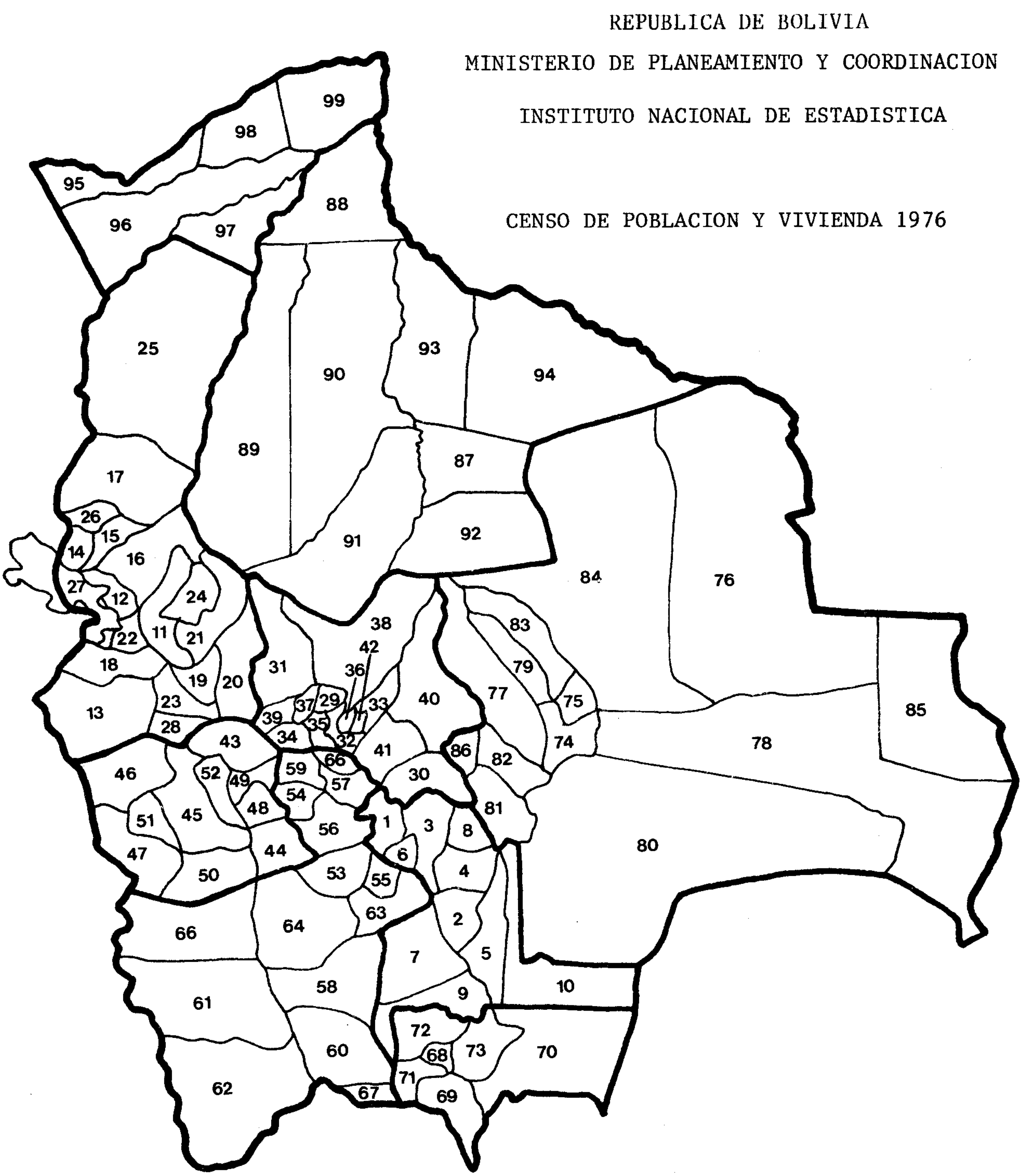

Figure 25. Numerical codes and location of the 99 provinces of Bolivia. Refer to Table 13 to obtain the names of the provinces.

Table 14.

NATURAL RESCURCE DATABASE

FILL CHARACTER INFORMATION SHEET

LEVEL CODE: 500 LEVEL NAME: REGIONAL

QUADRANT CODE: 10 QUADRANT NAME: ORURO

ELEMENT CODE: 4 ELEMENT NAME: SOCIO/ECONOMICAL INFORMATION

DEPARTMENT CODE: 4 NAME: ORURO FILL:( )

PROVINCE CODE: 44 NAME: AVAROA FILL:( )

CANTON CODE:	1	NAME: ANCACATO	FILL:(1)
CANTON CODE:	2	NAME: HUANCANE	FILL:(2)
CANTON CODE:	3	NAME: SANTIAGO DE HUARI	FILL:(3)
CANTON CODE:	4	NAME: KAKACHACA	FILL:(4)
CANTON CODE:	5	NAME: CONDO K	FILL:(5)
CANTON CODE:	6	NAME: CULTA	FILL:(6)
CANTON CODE:	7	NAME: URMIRI DE QUILLACAS	FILL:(7)
CANTON CODE:	8	NAME: GUADALUPE	FILL:(8)
CANTON CODE:	9	NAME: QUILLACAS	FILL:(9)
CANTON CODE:	10	NAME: SEVARUYO	FILL:(10)
CANTON CODE:	11	NAME: SORAYA DE QUILLACAS	FILL:(11)
CANTON CODE:	12	NAME: TURCO	FILL:(12)
CANTON CODE:	13	NAME: VILLCANI	FILL:(13)

PROVINCE CODE: 51 NAME: ATAHUALLPA FILL:( )

CANTON CODE:	1	NAME: SABAYA	FILL:(14)
CANTON CODE:	2	NAME: AYPARAVI	FILL:(15)
CANTON CODE:	3	NAME: BELLA VISTA	FILL:(16)
CANTON CODE:	4	NAME: CARANGAS	FILL:(17)
CANTON CODE:	5	NAME: CHIPAYA	FILL:(18)
CANTON CODE:	6	NAME: JULO	FILL:(19)
CANTON CODE:	7	NAME: LA RIVERA	FILL:(20)
CANTON CODE:	8	NAME: NEGRILLOS	FILL:(21)
CANTON CODE:	9	NAME: PACARIZA	FILL:(22)
CANTON CODE:	10	NAME: PARAJAYA	FILL:(23)
CANTON CODE:	11	NAME: PITACOLLO	FILL:(24)
CANTON CODE:	12	NAME: PISIGA	FILL:(25)
CANTON CODE:	13	NAME: CUEAQUIANI	FILL:(26)
CANTON CODE:	14	NAME: SACABAYA	FILL:(27)
CANTON CODE:	15	NAME: TODOS SANTOS	FILL:(28)
CANTON CODE:	16	NAME: TUNAPA	FILL:(29)
CANTON CODE:	17	NAME: VILLA VITALINA	FILL:(30)
CANTON CODE:	18	NAME: CRUZ DE HUAYLLAS	FILL:(31)
CANTON CODE:	19	NAME: COIPASA	FILL:(32)
CANTON CODE:	20	NAME: PAGADOR	FILL:(33)

PROVINCE CODE:	50	NAME: LADISLAO CABRERA	FILL:( )
CANTON CODE:	1	NAME: SALINAS DE GARCI MENDOZA	FILL:(34)
CANTON CODE:	2	NAME: ARCHA	FILL:(35)
CANTON CODE:	3	NAME: CONCEPCION DE BELEN	FILL:(36)
CANTON CODE:	4	NAME: CHALLACOTA	FILL:(37)
CANTON CODE:	5	NAME: JIRIRA	FILL:(38)
CANTON CODE:	6	NAME: SAN MARTIN	FILL:(39)
CANTON CODE:	7	NAME: TAMBILLO	FILL:(40)
CANTON CODE:	8	NAME: UCUMASI	FILL:(41)
CANTON CODE:	9	NAME: PAMPA AULLAGAS	FILL:(42)
PROVINCE CODE:	45	NAME: CARANGAS	FILL:( )
CANTON CODE:	1	NAME: CORQUE	FILL:(43)
CANTON CODE:	2	NAME: BELEN DE CHOQUECOTA	FILL:(44)
CANTON CODE:	3	NAME: BELLA VISTA	FILL:(45)
CANTON CODE:	4	NAME: CHAPAYA	FILL:(46)
CANTON CODE:	5	NAME: CHOQUECOTA	FILL:(47)
CANTON CODE:	6	NAME: CHUQUICHAMBI	FILL:(48)
CANTON CODE:	7	NAME: EDUARDO AVAROA	FILL:(49)
CANTON CODE:	8	NAME: HUAYLLAMARCA	FILL:(50)
CANTON CODE:	9	NAME: LLANQUERA	FILL:(51)
CANTON CODE:	10	NAME: OROQUERI	FILL:(52)
CANTON CODE:	11	NAME: PACOYO	FILL:(53)
CANTON CODE:	12	NAME: SAN ANTONIO DE NOR KHALA	FILL:(54)
CANTON CODE:	13	NAME: SAN JOSE DE LA KHALA	FILL:(55)
CANTON CODE:	14	NAME: SAN MIGUEL	FILL:(56)
CANTON CODE:	15	NAME: BELEN DE ANDAMARCA	FILL:(57)
CANTON CODE:	16	NAME: CRINOCA	FILL:(58)
CANTON CODE:	17	NAME: ANDAMARCA	FILL:(59)
PROVINCE CODE:	43	NAME: CERCADO	FILL:( )
CANTON CODE:	1	NAME: CARACOLLO	FILL:(60)
CANTON CODE:	2	NAME: CRUCERO DEL BELEN	FILL:(61)
CANTON CODE:	3	NAME: CHALLACOLLO	FILL:(62)
CANTON CODE:	4	NAME: EL CHORO	FILL:(63)
CANTON CODE:	5	NAME: LA JOYA	FILL:(64)
CANTON CODE:	6	NAME: PARIA	FILL:(65)
CANTON CODE:	7	NAME: TTE. BULLAIN	FILL:(66)
CANTON CODE:	8	NAME: VILACARA	FILL:(67)
CANTON CODE:	9	NAME: TOMAS BARRON	FILL:(68)
CANTON CODE:	10	NAME: ORURO	FILL:(244)
PROVINCE CODE:	49	NAME: PANTALEON DALENCE	FILL:( )
CANTON CODE:	1	NAME: HUANUNI	FILL:(69)
CANTON CODE:	2	NAME: MACHACAMARCA	FILL:(70)
CANTON CODE:	3	NAME: MOROCOCALA	FILL:(71)
CANTON CODE:	4	NAME: NEGRO PABELLON	FILL:(72)
CANTON CODE:	5	NAME: VICENTE ASCARRUNZ	FILL:(73)

PROVINCE CODE: 47 NAME: LITORAL FILL:( )

CANTON CODE: 1	NAME: HUACHACALLA	FILL:(74)
CANTON CODE: 2	NAME: BELLA VISTA	FILL:(75)
CANTON CODE: 3	NAME: ROMERO PAMPA	FILL:(76)
CANTON CODE: 4	NAME: YUNGUYO DEL LITORAL	FILL:(77)
CANTON CODE: 5	NAME: ESCARA	FILL:(78)
CANTON CODE: 6	NAME: PAYRUMANI DE LITORAL	FILL:(79)
CANTON CODE: 7	NAME: YUNGUYO	FILL:(80)
CANTON CODE: 8	NAME: CRUZ DE MACHACAMARCA	FILL:(81)
CANTON CODE: 9	NAME: FLORIDA	FILL:(82)
CANTON CODE: 10	NAME: ESMERALDA	FILL:(83)

PROVINCE CODE: 48 NAME: POOPO FILL:( )

CANTON CODE: 1	NAME: POOPO	FILL:(84)
CANTON CODE: 2	NAME: ANTEQUERA	FILL:(85)
CANTON CODE: 3	NAME: THOLA PAMPA	FILL:(86)
CANTON CODE: 4	NAME: VENTAIMEDIA	FILL:(87)
CANTON CODE: 5	NAME: PAZNA	FILL:(88)
CANTON CODE: 6	NAME: AVICAYA	FILL:(89)
CANTON CODE: 7	NAME: PENAS	FILL:(90)
CANTON CODE: 8	NAME: TOTORAL	FILL:(91)
CANTON CODE: 9	NAME: URMIRI	FILL:(92)

PROVINCE CODE: 46 NAME: SAJAMA FILL:( )

CANTON CODE: 1	NAME: CURAHUARA DE CARANGAS	FILL:(93)
CANTON CODE: 2	NAME: HUANCANAPE	FILL:(94)
CANTON CODE: 3	NAME: MARQUIRIRI	FILL:(95)
CANTON CODE: 4	NAME: SAJAMA	FILL:(96)
CANTON CODE: 5	NAME: TOTORA	FILL:(97)
CANTON CODE: 6	NAME: TURCO	FILL:(98)
CANTON CODE: 7	NAME: COSAPA	FILL:(99)
CANTON CODE: 8	NAME: CHACHACOMANI	FILL:(100)
CANTON CODE: 9	NAME: HUAJRIRI	FILL:(101)
CANTON CODE: 10	NAME: MACOYO	FILL:(102)

PROVINCE CODE: 52 NAME: SAUCARI FILL:( )

CANTON CODE: 1	NAME: VILLA TOLEDO	FILL:(103)
CANTON CODE: 2	NAME: CATUYO	FILL:(104)
CANTON CODE: 3	NAME: KARI KARI	FILL:(105)
CANTON CODE: 4	NAME: CHALLAVITO	FILL:(106)
CANTON CODE: 5	NAME: CHOCARASI	FILL:(107)
CANTON CODE: 6	NAME: CHUQUINA	FILL:(108)
CANTON CODE: 7	NAME: CULLURI	FILL:(109)
CANTON CODE: 8	NAME: SAUCARI	FILL:(110)
CANTON CODE: 9	NAME: UTAVI	FILL:(111)

DEPARTMENT CODE: 2 NAME: LA PAZ FILL:(242)

DEPARTMENT CODE: 3 NAME: COCHABAMBA FILL:(243)

DEPARTMENT CODE: 5 NAME: POTOSI FILL:(245)

DEPARTMENT CODE: 251 NAME: CHILE FILL:(251)

LARS in the near future (see arrival schedule in Figure 1) will consist of assigning digital codes (fill characters) to every class within the various data base elements. The coding performed to date, in addition to other equally important project tasks would not have been possible to carry out without the valuable and indispensible assistance from the Bolivian Visiting Scientist, Ing. Carlos Valenzuela.

INPUT OF THE DATA BASE ELEMENTS

General Background

As stated in the previous Quarterly Progress Report, the process by which geo-referenced data, i.e., spatial data contained in a standard map format, is converted to a suitable format for input and storage in a digital computer is known as "digitization". This process is also referred to as "encoding", "data capture", or "data input", and it can be done either manually or by means of special hardware and software systems. Experience at LARS and elsewhere has shown that this process is extremely time consuming, particularly when it is done manually. Therefore, an important task of this project was to develop an efficient, effective, and user-oriented "data input" system. Figure 8 in the previous Quarterly Progress Report shows diagrammatically and in a simplified form the major processing steps of the data input system for which software had to be developed. The development, implementation, and testing of the data input system was performed according to the proposed project implementation plan shown in Figure 1 of this report, i.e., during the period October 1, 1980 through February 15, 1981 as illustrated by the sequence of dots in Figure 1.

The Digitizing Hardware System

The basic hardware conponents of the digitizing (data input) system developed at LARS include:

- A TALOS table digitizer (see Appendix C)
- A PDP 11/34 computer (see Appendix G)
- An IBM 3031 computer (see Appendix H)
- A COMTAL Vision One/20 image display (see Appendix B)
- A TEKTRONIX 4054 graphics terminal (see Appendix F)
- A VARIAN dot-matrix printer/plotter
- Interactive terminals.

Detailed descriptions of each of these hardware components is included in the respective Appendices of this report.

The Digitizing Software System

As previously stated, extensive software development was accomplished during the present reporting period. Several computer programs were written and integrated into a complete "data input" system. Figure 26 shows a diagram that illustrates the data flow, the various processes involved, and the logic of this data input system. The input to the system is a standard map, and the output consists of a computer magnetic tape containing a gridded (rasterized) digital image (in an Albers projection) of the input map. Detailed user and system documentation of the data input system shown in Figure 26 will be included in the next Quarterly Progress Report. As of January 31, 1981, a test of this data input system was successfully completed. Presently, the Political divisions map of the Oruro Department is being prepared to be digitized using this data input system.

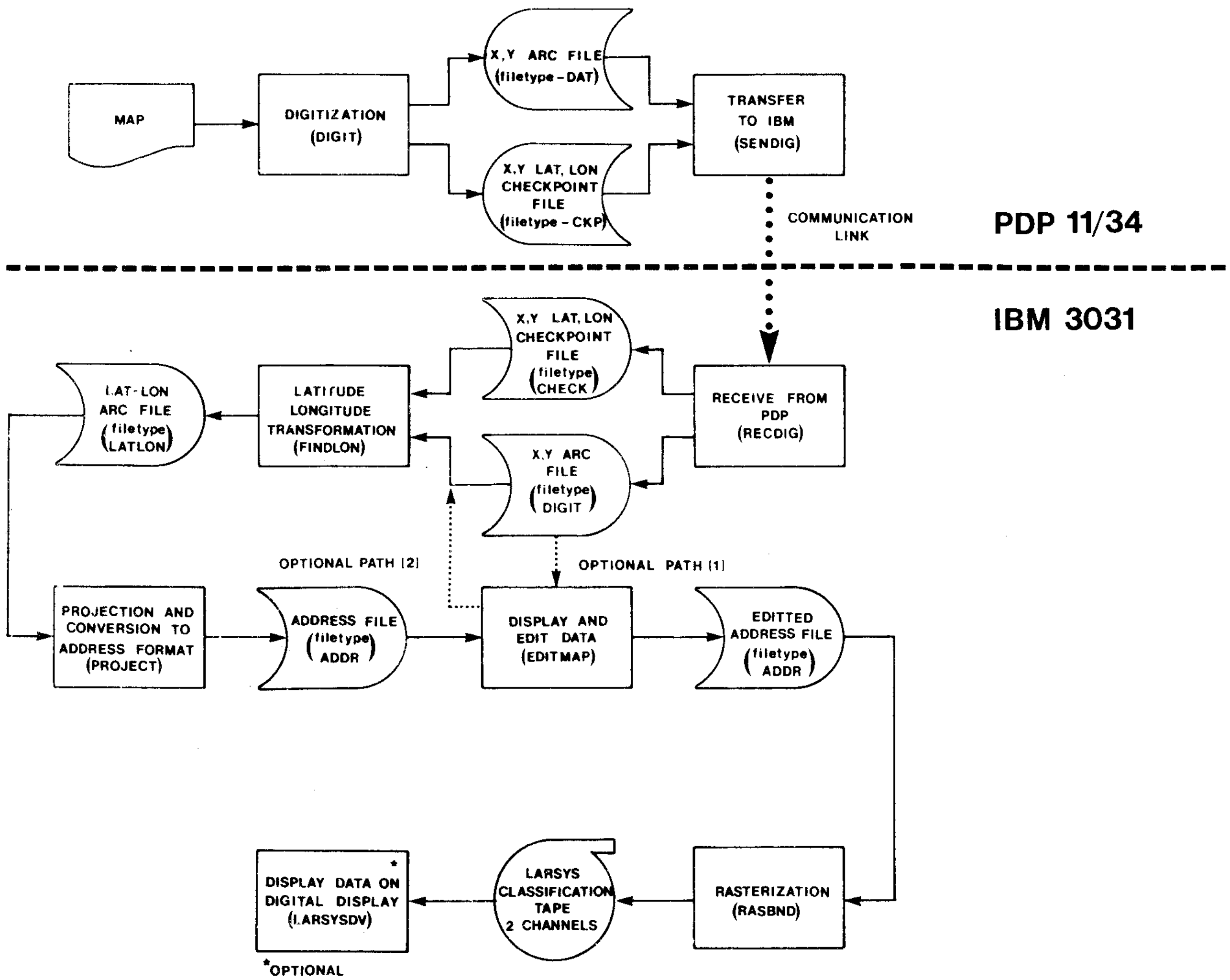

Figure 26. Data input (digitizing) system as of January 31, 1981.

ESTIMATED EXPENSES THROUGH DECEMBER 31, 1980

The estimated cost of this project for the period July 1, 1980 through the end of the 1980 calendar year is shown in Table 15. All expenses incurred until December 31, 1980 have been combined into five major categories, which are related to the different tasks shown in the proposed project implementation plan (Figure 1).

Table 15. Cost Estimate Corresponding to the Period July 1, 1980 through December 31, 1980 For the Geographic Information System of Oruro, Bolivia Project.

Task No.[1]	Major Tasks	Personnel	SS[2]	Travel	Other	Total
1, 2, 7, 8	System Design and GEOBOL Interface	$20,232	$ 28	$4,824	$ 629	$25,713
3, 4, 13	Digital Mozaic	10,000	7,500		100	17,600
5	Data Base Systems Development	8,000	7,200			15,200
	Training	2,000			35,951	37,951
6	Data Base Creation					
	TOTAL	$40,232	$14,728	$4,824	$36,680	$96,464

[1] Refers to task numbers in Figure 1.

[2] Computer Service

REFERENCES

Tessar, Paul A., and Loyola M. Caron (1980), "A Legislator's Guide to Natural Resources Information Systems", National Conference of State Legislators (NCSL), 1125 Seventeenth Street, Suite 1500, Denver, Colorado, June 1980.

Zobrist, Albert L. (1978), "Multi-Frame, Full Resolution Landsat Mosaicking to Standard Map Projections", Jet Propulsion Laboratory, Pasadena, California, pp: 608-616.

APPENDIX A

Desaguadero

LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER................ 77010501
DATE TAPE GENERATED..... FEB 6,1981
TAPE NUMBER.................... 5283
FILE NUMBER....................... 1
LINES OF DATA.................. 2340
SECONDS OF DATA............... 28.65
MILES OF DATA................ 100.50
LINE RATE........... 81.68 LINES/SEC
FRAME CENTER LATITUDE......... -17.36

FLIGHTLINE ID......... 295713271 BOLI
DATE DATA TAKEN............... 9/ 8/77
TIME DATA TAKEN............. 0827 HOURS
PLATFORM ALTITUDE......... 3062000 FEET
GROUND HEADING............ 189 DEGREES
FIELD OF VIEW........... 0.273 RADIANS
DATA SAMPLES PER CHANNEL PER LINE 3208
SAMPLE RATE........ 0.09 MILLIRADIANS
FRAME CENTER LONGITUDE.......... 68.11

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 77010501 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 77010500
THE FOLLOWING LINES, CHANNELS WERE REPLACED IN RUN 77010501:

LINE 253, CHANNEL 3
LINE 353, CHANNEL 3
LINE 545, CHANNEL 3
LINE 1017, CHANNEL 1
LINE 1053, CHANNEL 3
LINE 1322, CHANNEL 3
LINE 1474, CHANNEL 2
LINE 1849, CHANNEL 3

LINE 329, CHANNEL 2
LINE 478, CHANNEL 3
LINE 721, CHANNEL 3
LINE 1039, CHANNEL 3
LINE 1309, CHANNEL 3
LINE 1394, CHANNEL 3
LINE 1641, CHANNEL 3

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Oruro

LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER................. 76022501	FLIGHTLINE ID......... 540913134 ECLI
DATE TAPE GENERATED..... SEPT 17,1980	DATE DATA TAKEN............... 6/ 5/77
TAPE NUMBER.................... 5286	TIME DATA TAKEN............. 0813 HOURS
FILE NUMBER.................... 1	PLATFORM ALTITUDE......... 3062000 FEET
LINES OF DATA.................. 2328	GROUND HEADING............. 189 DEGREES
SECONDS OF DATA................ 28.50	FIELD OF VIEW........... 0.270 RADIANS
MILES OF DATA.................. 55.55	DATA SAMPLES PER CHANNEL PER LINE 3176
LINE RATE........... 81.68 LINES/SEC	SAMPLE RATE....... 0.09 MILLIRADIANS
FRAME CENTER LATITUDE......... -17.33	FRAME CENTER LONGITUDE.......... 66.86

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 6022501 WAS FORMED BY THE SHIFTD PROCESSOR FROM RUN 76022500.
COLUMNS 790 TO 2382 WERE SHIFTED UP 12 LINES RELATIVE TO THE REST OF THE DATA SET.

Salar de Coipasa

LARS FORM - 17D

DATA STORAGE TAPE FILE

RUN NUMBER.................. 77010601 FLIGHTLINE ID......... 293913284 BOLI
DATE TAPE GENERATED..... FEB 6,1981 DATE DATA TAKEN............... 8/21/77
TAPE NUMBER................... 5272 TIME DATA TAKEN............. 0828 HOURS
FILE NUMBER..................... 1 PLATFORM ALTITUDE......... 3062000 FEET
LINES OF DATA.................. 2340 GROUND HEADING............. 190 DEGREES
SECONDS OF DATA............... 28.65 FIELD OF VIEW........... 0.273 RADIANS
MILES OF DATA................ 100.50 DATA SAMPLES PER CHANNEL PER LINE 3208
LINE RATE.......... 81.68 LINES/SEC SAMPLE RATE........ 0.09 MILLIRADIANS
FRAME CENTER LATITUDE....... -18.76 FRAME CENTER LONGITUDE.......... 68.39

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 77010601 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 77010600.
THE FOLLOWING LINES, CHANNELS WER REPLACED IN RUN 77010601:

LINE 798, CHANNEL 2 LINE 930, CHANNEL 4
LINE 973, CHANNEL 3 LINE 1009, CHANNEL 3
LINE 1015, CHANNEL 3 LINE 1046, CHANNEL 3
LINE 1105, CHANNEL 3 LINE 1111, CHANNEL 3
LINE 1135, CHANNEL 3 LINE 1201, CHANNEL 3
LINE 1207, CHANNEL 3 LINE 1284, CHANNEL 2
LINE 1360, CHANNEL 4 LINE 1509, CHANNEL 3
LINE 2149, CHANNEL 4 LINE 2167, CHANNEL 3
LINE 2209, CHANNEL 3 LINE 2212, CHANNEL 1
LINE 2221, CHANNEL 3 LINE 2317, CHANNEL 1

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Lago Poopo

LARS FORM - 17D

DATA STORAGE TAPE FILE

RUN NUMBER................	76022401	FLIGHTLINE ID..........	540913140 BOLI
DATE TAPE GENERATED.....	FEB 6,1981	DATE DATA TAKEN...............	6/ 5/76
TAPE NUMBER....................	3759	TIME DATA TAKEN...............	0814 HOURS
FILE NUMBER.....................	1	PLATFORM ALTITUDE.........	3062000 FEET
LINES OF DATA..................	2340	GROUND HEADING.............	190 DEGREES
SECONDS OF DATA...............	28.65	FIELD OF VIEW...........	0.270 RADIANS
MILES OF DATA.................	100.50	DATA SAMPLES PER CHANNEL PER LINE	3176
LINE RATE............	81.68 LINES/SEC	SAMPLE RATE........	0.09 MILLIRADIANS
FRAME CENTER LATITUDE.........	-18.78	FRAME CENTER LONGITUDE..........	67.21

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 76022401 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 76022400.

THE FOLLOWING LINES, CHANNELS WERE REPLACED IN RUN 76022401:

LINE 24, CHANNEL 2	LINE 54, CHANNEL 1-2	LINE 114, CHANNEL 2
LINE 234, CHANNEL 2	LINE 240, CHANNEL 1	LINE 258, CHANNEL 2
LINE 264, CHANNEL 1-2	LINE 293, CHANNEL 2	LINE 323, CHANNEL 2
LINE 324, CHANNEL 1	LINE 353, CHANNEL 2	LINE 354, CHANNEL 1
LINE 383, CHANNEL 2	LINE 384, CHANNEL 1	LINE 623, CHANNEL 1-2
LINE 624, CHANNEL 1	LINE 894, CHANNEL 1	LINE 1163, CHANNEL 2
LINE (1293, 1355, 6), CHANNEL 1		LINE 1395, CHANNEL 3
LINE (1401, 1473, 6), CHANNEL 1		LINE 1974, CHANNEL 2
LINE (2255, 2339, 6), CHANNEL 2		

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LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER.................. 79CC5801 FLIGHTLINE ID.......... 660113340 EOLI

DATE TAPE GENERATEC..... FEB 5,1981 DATE DATA TAKEN................ 6/16/79

TAPE NUMBER.................... 1353 TIME DATA TAKEN............ 0834 HOURS

FILE NUMBER...................... 1 PLATFORM ALTITUDE.......... 3062000 FEET

LINES OF DATA.................. 2340 GROUND HEADING.............. 19C DEGREES

SECONDS OF DATA............... 28.65 FIELD CF VIEW........... 0.273 RADIANS

MILES OF DATA................ 10C.50 DATA SAMPLES PER CHANNEL PER LINE 3208

LINE RATE........... 81.68 LINES/SEC SAMPLE RATE....... 0.09 MILLIRADIANS

FRAME CENTER LATITUCE......... -18.76 FRAME CENTER LONGITUDE.......... 65.69

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 79005801 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 79005800.
THE FOLLOWING LINES, CHANNELS WERE REPLACED IN RUN 79005801:

LINE 100, CHANNEL 1,4	LINE 185, CHANNEL 4	LINE 304, CHANNEL 4
LINE 323, CHANNEL 4	LINE 345, CHANNEL 3	LINE 364, CHANNEL 4
LINE 415, CHANNEL 4	LINE 416, CHANNEL 4	LINE 523, CHANNEL 4
LINE 535, CHANNEL 3	LINE 640, CHANNEL 2,4	LINE 772, CHANNEL 4
LINE 808, CHANNEL 4	LINE 868, CHANNEL 4	LINE 892, CHANNEL 4
LINE 904, CHANNEL 4	LINE 1192, CHANNEL 4	LINE 1252, CHANNEL 4
LINE 1312, CHANNEL 4	LINE 1313, CHANNEL 4	LINE 1550, CHANNEL 3
LINE 1654, CHANNEL 4	LINE 1924, CHANNEL 4	LINE 1960, CHANNEL 4
LINE 1981, CHANNEL 4	LINE 2223, CHANNEL 4	LINE 2224, CHANNEL 4
LINE 2263, CHANNEL 2	LINE 2284, CHANNEL 4	LINE 2338, CHANNEL 4

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Salar de Empexa

LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER.................. 77010701	FLIGHTLINE ID......... 292913290 EOL I
DATE TAPE GENERATED..... FEB 10.1981	DATE DATA TAKEN............... 8/21/77
TAPE NUMBER.................... 5278	TIME DATA TAKEN............ 0829 HOURS
FILE NUMBER...................... 1	PLATFORM ALTITUDE......... 3062000 FEET
LINES OF DATA.................. 2340	GROUND HEADING............. 190 DEGREES
SECONDS OF DATA............... 28.65	FIELD OF VIEW............ 0.273 RADIANS
MILES OF DATA................ 100.50	DATA SAMPLES PER CHANNEL PER LINE 3208
LINE RATE.......... 81.68 LINES/SEC	SAMPLE RATE........ 0.05 MILLIRADIANS
FRAME CENTER LATITUDE......... -20.21	FRAME CENTER LONGITUDE.......... 68.74

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)			(6)		
(7)			(8)			(9)		
(10)			(11)			(12)		
(13)			(14)			(15)		
(16)			(17)			(18)		
(19)			(20)			(21)		
(22)			(23)			(24)		
(25)			(26)			(27)		
(28)			(29)			(30)		

DATA TAPE COMMENTS...

RUN 77010701 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 77010700.

THE FOLLOWING LINES, CHANNELS WERE REPLACED IN RUN 77010701:

LINE 43, CHANNEL 3	LINE 97, CHANNEL 1	LINE 129, CHANNEL 1
LINE 247, CHANNEL 3	LINE 411, CHANNEL 2	LINE 416, CHANNEL 3
LINE 580, CHANNEL 4	LINE 693, CHANNEL 1	LINE 1072, CHANNEL 4
LINE 1368, CHANNEL 2	LINE 1649, CHANNEL 2	LINE 1668, CHANNEL 3
LINE 1688, CHANNEL 3	LINE 1699, CHANNEL 3	LINE 1868, CHANNEL 3
LINE 1987, CHANNEL 3	LINE 2131, CHANNEL 2	LINE 2185, CHANNEL 3
LINE 2250, CHANNEL 2		

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Salar de Uyuni

LARS FORM - 170

DATA STORAGE TAPE FILE

RUN NUMBER.................. 77010301	FLIGHTLINE ID.......... 293813232 EOVI
DATE TAPE GENERATED..... FEB 12,1981	DATE DATA TAKEN............... 8/20/77
TAPE NUMBER.................... 5279	TIME DATA TAKEN............ 0823 HOURS
FILE NUMBER........................ 1	PLATFORM ALTITUDE......... 3062000 FEET
LINES OF DATA................... 2340	GROUND HEADING............ 190 DEGREES
SECONDS OF DATA................ 28.65	FIELD OF VIEW........... 0.273 RADIANS
MILES OF DATA.................. 100.50	DATA SAMPLES PER CHANNEL PER LINE 3208
LINE RATE........... 81.68 LINES/SEC	SAMPLE RATE........ 0.09 MILLIRADIANS
FRAME CENTER LATITUDE......... -20.23	FRAME CENTER LONGITUDE.......... 67.33

SPECTRAL BANDWIDTH IN MICROMETERS..

CHAN	LOWER	UPPER	CHAN	LOWER	UPPER	CHAN	LOWER	UPPER
(1)	0.50	0.60	(2)	0.60	0.70	(3)	0.70	0.80
(4)	0.80	1.10	(5)	-----	-----	(6)	-----	-----
(7)	-----	-----	(8)	-----	-----	(9)	-----	-----
(10)	-----	-----	(11)	-----	-----	(12)	-----	-----
(13)	-----	-----	(14)	-----	-----	(15)	-----	-----
(16)	-----	-----	(17)	-----	-----	(18)	-----	-----
(19)	-----	-----	(20)	-----	-----	(21)	-----	-----
(22)	-----	-----	(23)	-----	-----	(24)	-----	-----
(25)	-----	-----	(26)	-----	-----	(27)	-----	-----
(28)	-----	-----	(29)	-----	-----	(30)	-----	-----

DATA TAPE COMMENTS...

RUN 77010301 WAS FORMED BY THE EDRUN PROCESSOR FROM RUN 77010300.
THE FOLLOWING LINES, CHANNELS WERE REPLACED IN RUN 77010301:

LINE 1002, CHANNEL 1	LINE 1033, CHANNEL 1	LINE 1129, CHANNEL 1
LINE 1145, CHANNEL 1	LINE 1259, CHANNEL 1	LINE 1321, CHANNEL 1
LINE 1460, CHANNEL 3	LINE 1503, CHANNEL 3	LINE 1509, CHANNEL 3
LINE 1517, CHANNEL 1	LINE 1534, CHANNEL 1	LINE 1565, CHANNEL 1
LINE 1573, CHANNEL 1	LINE 1581, CHANNEL 1	LINE 1597, CHANNEL 1
LINE 1629, CHANNEL 3	LINE 1633, CHANNEL 1	LINE 2047, CHANNEL 2
LINE 2052, CHANNEL 2		

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APPENDIX B

COMTAL IMAGE PROCESSING SYSTEMS

COMTAL CORPORATION 505 West Woodbury Road, Altadena, California 91001 • (213) 797-1175 TWX 910-588-3256

Vision One/20 Configuration Document

Effective
March 1, 1980

Model	Description

A sophisticated state-of-the-art digital image exploitation system. Self-contained with multi-purpose programmable processors and large data bases. Performs as a stand-alone or coupled processor to numerous host computers. Vision One/20's are designed to be field upgradable to complement expanded applications where large (to 4096^2) data bases are required, or where added processing, arithmetic capability and/or additional users are needed.

Vision One/20 Image Processor with the capacity for 64 512x512-8 bit images (or 16 1024x1024-8 bit data base image) with 512x512 display output.

This Model includes:

a) Image processor and controller
b) Image processing and control firmware
c) Operator assignment of image memory to a spatially contiguous data base or discreet images
d) Real-time roam of a 512x512 display window within a large data base image
e) Real-time zoom (2x and 4x) and simultaneous roam
f) Keyboard controller with 20 special function keys programmed by firmware and/or operator definition
g) Alphanumeric prompting on primary video output
h) COMTAL standard image processing system I/O interface
i) Processor and controller bus interface
j) Processor and controller program memory expansion for user generated software
k) Diagnostic and set-up commands
l) Test pattern generator
m) Precise, movable, digital, 16x16 programmable target/cursor
n) Complete "feedback" of displayed images as well as from all processing and refresh memories plus target coordinates
o) Three full 8-bit (256 level) 10M pixel/sec. digital to analog converters
p) Pseudocolor processor (24 bit output, 8 bits each, red, green, and blue)
q) High resolution pseudocolor, black and white, true or false color
r) Independent pipeline processor slots

Vision One/20 Configuration Document (cont'd)

Model	Description
	s) Random access refresh memories may be loaded and/or read on a single pixel or continuous line basis with one set of transfer commands t) The refresh output spatial relationship of all image and or graphic memories may be altered at will and in any direction under hardware control. Full roam, and scrolling operations are included. Field upgrade capability to 64 512x512-8 bit images (or one 4096x4096-8 bit image) and/or independent processing/display user stations.
	The above capability includes the following cards and other items:
PMEM-1	Program Memory in firmware, 12K words
SYSC	System Computer includes up to 16K words RAM
CSIO	COMTAL Standard Input/Output (for HP host, order CSIOHP)
OVLY	Overlay Card
ANDV	Ancillary Device Card
KB	Keyboard
DACC-9	Digital to Analog (512) Converter
CHPS	Chassis for cards (two backplane capability) rack slides, one power supply and one backplane
	To complete a system one must decide upon the size of the image/graphic refresh memory, trackball and/or data tablet, computer controller (when the system is to be operated with an external computer) and/or tape system for stand-alone operations, monitor, color or black and white and equipment mounting hardware or furniture if desired. Image/graphic refresh memory sizes determine the number of memory cards, I/O cards, refresh control cards, frame write cards, pipeline processor cards, backplanes chassis and power supplies.
	The above items are listed as:
REFM	Refresh Memory Card (1M bit)
RANC	Random I/O Memory Control Card, one card supports eight images
REFC	Refresh Control Card (roam,zoom), one card supports eight images

Vision One/20 Configuration Document (cont'd)

Model	Description
FRMW	Frame Write Feedback Card, one card supports eight images
PLP-4	Pipeline Processor, one card supports four images
TB	Trackball (other interactive devices available - see options)
CT-8H	Very High Resolution Monitor
CONT-X	Typical Interface Card includes 25 ft. cable
DD	Data Desk (Single Bay)

EXPANSION OPTIONS

Model	Description
VID	Video Digitizer - Samples and converts to 8-bit value an input analog video signal synchronous with the display. Stores the results in one image refresh storage. Requires assignment of one image in PLP capacity (may require additional PLP-4).
DVID	Digital Video Input Port - 10M byte/sec for digital video or simulated video input. Modification to frame write card (requires FRMW).
CONLV-H	Convolution Processor - A plug-in unit for Vision One/20 systems that provides real-time convolution of up to four images (may require EXP).
ICOM	Image Combine Option - Real-time add, subtract, multiply, or divide between two images (may require EXP).
CLSF	Real-Time Multispectral Parallel-Piped Data Classifier and Classified Pixel Counter - This option provides the capability to support a real-time classification of up to four bands of multispectral data. Up to four separate classes may be displayed simultaneously with this option. The resultant classified areas are instantly displayed in selected colors on a false color or monochrome image presentation. The classified pixel counter counts the number of classified pixels for a selected class within the total image. This value may be read on the Vision One/20 annotation screen or by an external device over the system interface. *Provision is made for displaying overlapping classified areas in unique operator selected colors. *Any one of over 16 million color combinations may be assigned to each class. *Decision criteria may be entered via the local keyboard or by an external device, over the system interface. *Complete flexibility is provided in decision criteria since the user is not restricted to utilizing upper and lower limits. Up to 128 "on-off" decisions may be exercised per spectral plane. This option is implemented as a plug-in card for the classification using four images or less. An additional card provides for the classification of up to eight images at a time, etc. (may require an EXP).
SMAP	Real-Time Independent Small Area Processing for local color correction and other small area pipeline modification (needs one additional function memory per four images to have SMAP

Model	Description
	capability).
TLU-168	Table Look-Up 16x8 bits provides arbitrary loadable 16x8 (65K input by 256 output) function memory for handling very large dynamic range images. (Firmware interprets two 512x512-8 bit images as one 512x512-16 bit image.)
SWCH	Switchable - Output raster from 559 to 525 1:1 aspect ratio for driving external TV industry devices at 525 line 60 field rates.
TVSY	External Synchronization - Accepts composite sync for driving the Vision One/20 from external devices (525/625 option, includes SWCH).
COZO	Continuous Zoom option in hardware for 1x up to 512x in steps of .002x. (Replication, bilinear interpolation, cubic interpolation, selectable.)
RAMC	LSI-11 RAM Memory available for users desiring soft operating system (16K words). (Replaces PMEM-1.)
SLNI	Serial Line Interface - RS232 compatible variable baud rate for standard interfacing.
DIFF	Differential drives for 500' remote location of TB, KB, TAB, SHAFT (customer to supply cabling, and any special cabling required to maintain fidelity on the monitor).
DACC-10	Digital to Analog Converter Card for 1024x1024 display output. Runs at 40 Megapixels/sec and has three channel (R,G,B) per card.
CCOR	Color Computer - Provides 24x24 bit RGB or YMC coupled mapping of input colors to output colors in real-time (includes SHAFT option).
OVLY-2	Overlay Card for second "dual" programmable target.
AUC	Independent Image Processing Channel for a second user - Provides independent image processing and display output. Both primary and secondary user channels operating from shared 512x512 images refresh memory (requires an EXP). This option includes PLP-4, OVLY, ANDV, KB, DACC-9 (monitor not included). Prices vary based on capability of second channel.
MAPPER	Mapper for 6 degree of freedom hardware spatial warping (rotation, scaling, translation, skew) from source data base to destination image in 1/5 second.

Model	Description
	a) Basic system (1 bit deep, 1024^2 source image) b) Each additional 1-bit of source memory c) 2048^2 source data base available (may require EXP)
SHAFT	Control Box for continuous interactive control of four independent parameters.
CT-8HH	Monitor - Very high spatial resolution color monitor with square aspect ratio presentation on a 19" (diagonal) CRT screen for use with 1024x1024 resolution processors.
BT-17	Monitor - Very high spatial resolution 512x512 monochrome monitor with square aspect ratio presentation on a 17" (diagonal) CRT screen.
BT-2	Monitor - Very high spatial resolution black and white monitor with square aspect ratio presentation on a 17" (diagonal) CRT screen for use with 1024x1024 spatial resolution processors.
DTT	Digital Tape Transport - IBM compatible 800 bpi 45 IPS magnetic tape and controller for input/output for Vision One/20 systems (requires DD1 for mounting).
DTT-2	Digital Tape Transport - Dual density IBM compatible 1600/800 bpi 75 IPS magnetic tape and controller for input/output for Vision One/20 systems (requires DD1 for mounting).
DTT-3	Digital Tape Transport - Dual density IBM compatible 1600/800 bpi 125 IPS magnetic tape and controller for input/output for Vision One/20 systems (requires DD1 for mounting).
DD1	Data Desk - Desk sized to accept a Vision One/20 and a DTT-X Digital Tape Transport (Double bay).
VRMT	Vertical Mount - Standard 19" rack mount and cabinet
EXP	Expansion Backplane and Power Supply
CAM	Camera - Self-contained high quality vidicon camera with shading corrector. Compatible with VID option. (Standard RS-170 separate H & V sync). Includes stand.
TAB-A	Data Tablet - 11"x11" XY tablet for "pen on surface" control of target location and other interactive programmable operations.
TAB-B	Data Tablet - 11"x17"

Model	Description
TAB-C	Data Tablet - 24"x24"
CAB	50 ft. Cable instead of 25 ft. (see CONT-X)
VREFM	200 Mbyte dual ported fixed media mass storage disc. Includes controller, formatter, adapter, O/S driver (Winchester technology fixed media).
SYSC-23	LSI-11/23 system computer for replacement of SYSC. Program memory includes maximum of 128K words.
NOS-P	Replacement Firmware - Operating system for those wishing to define specific requirements after delivery of standard operating system (includes listing and new PMEM).
NOS-S	Replacement Software - Operating system for those users wishing to define specific requirements after delivery of standard operating system (includes listing and 9 track tape) (requires RAMC).
DOCM	Documentation - Full documentation of wire lists, signal lists, schematics, user manual and programmer card (first set provided at no charge).
INST	System Installation - At customer prepared site by COMTAL field service personnel. Travel and living expenses are extra, charged at cost (includes 3 hour training).
TRAIN	Training - Because the Vision One/20 can be configured to be a highly sophisticated digital processing device, up to a full week of in-house training is available for two people. Each additional trainee is extra.
MAIN	Maintenance - Contract available on an annual basis (priced at 7% sale price per year plus one-time zone charge. Sample contract available upon request). Required with lease customers. Extended warranty priced at 0.9% on a month-to-month basis.
BRDX	Board Exchange - Special program to provide user with replacement of faulty circuit card, 24-48 hour turn-around, if exchange card is available. (Details in standard maintenance agreement.)
ONCL	On-Call Service - Cost based on time and materials plus travel and living expenses. (See details in standard maintenance agreement.)
ACFAC	Factory Acceptance - Test procedure for up to 2 customer personnel in accordance with COMTAL specified testing procedure.

Model	Description
ACSIT	On-Site Acceptance - Test procedure if performed in conjunction with COMTAL installation and in accordance with COMTAL specified testing procedures. If performed without installation, add actual costs for transportation and living expenses.
HIST	Real-Time Histogram and statistical processor
GRAPH	Graphic package to include special symbols, bars, charts, vector/raster converter, and general raster graphics functions of the Computer-Graphics marketplace (includes 7x9 alpha-numeric generator with 128 ASCII characters).
CONVL-S	Convolver package for implementation of recursive 3x3 convolutions in software without real-time hardware. Requires FRMW, ICOM, and 9 iterations per 3x3 convolution (9 times slower than CONLV-H).
VIDINT	Video Integration - Software package for accumulating multiple sums of video input carrying 16 bits of precision prior to final truncation back to 8 bits/pixel. Requires 4 image planes plus VID and ICOM option.
DVID-L	Line buffered DVID facilitates asynchronous line loading at 10M byte/sec rates without frame delay.
OVER	Overview hardware/software calculator provides scene overview from refresh memory to 512x512 output in less than one second, or to 1024x1024 output in less than four seconds.

APPENDIX C

TALOS TABLE DIGITIZER

Functional Description

The ingenious circuits of the active-inch electronics unit are designed to exploit the characteristics of the Talos digitizing surfaces. A proprietary electronic servo loop and switching circuit activates a single 1" x 1" area on the digitizing surface which automatically surrounds the pen or cursor with an electrical field wherever it is, or goes, on the entire active surface. The transducer in the pen or cursor senses this field, generating signals that are returned to the electronics unit where they are converted to "numbers" in the desired digital code which represent the absolute (i.e., referred to the active surface origin) X and Y coordinates of pen or cursor positions. The "numbers" are actually a sequence or group of logic voltage levels suitable for transmitting to the computer for display or other uses.

The active-inch electronics, in combination with the extremely precise, unchanging digitizing surface, can resolve any inch in both the X and Y directions into 1,000 divisions of length, usually expressed as lines-per-inch of resolution. Because of this capability and the fact that the electronics know exactly how far each line is located from the origin, the Talos Digitizers measure absolute position; that is, the coordinates of the pen or cursor are absolute with respect to the surface origin. They are able to provide an absolute accuracy of ±0.01" standard; ±0.005" optional.

In addition to high resolution and accuracy, the operating principle provides several other important benefits.

Stability: Component aging, temperature variations and input power have no effect on performance.

Interchangeability: Different surfaces can be interchanged with the electronics unit and modules inside the electronics unit can be interchanged.

Calibration: Unlike other digitizers, the Talos digitizers require no periodic recalibration or maintenance of any kind to maintain its precision.

Origin: The origin cannot be lost; that is, the pen or cursor can be lifted and returned to the surface with no effect on previous work.

Environment: Unlike other digitizers, the Talos digitizers are not effected by magnetic or electrical fields, temperature variations, drafts, humidity, dust or noise.

Versatility: Only Talos offers a complete family of digitizers.

Interfaceability: The modular construction of the Talos digitizers allows the interface of your choice to be an integral part of the digitizer electronics. Select from a wide variety of interfaces to meet your specific requirements.

Three different digitizer surface configurations:

- **Solid:** For a smooth, hard digitizing surface.
- **Back-Lighted:** For digitizing X-rays, printed circuit, and other negatives.
- **Rear Projected:** For digitizing projected images from movies, slides, and other projections.

Two different system concepts:

- **The Standard One™:** The digitizer that has established the standards that other digitizers try to meet. Outputs coordinate positions for the user to process as desired.
- **The Smart One™:** A microprocessor based unit that provides internal processing of precision coordinate positions. Allows relocation or origin, skew correction, scaling and other convenient local processing capabilities.

™ This is a Trade Mark of Talos Systems, Inc.

TALOS SYSTEMS INC. • 7419 E. Helm Drive • Scottsdale, Arizona 85260 • (602) 948-6540 TWX (910) 950-1183

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DETAILED SPECIFICATIONS

Unless otherwise noted, these specifications are for both The Standard One and The Smart One digitizers.

Resolution: The Standard One provides resolutions in either English (1000 lines per inch) or Metric (40 lines per cm). Optional resolutions available in Metric (100 and 400 lines per cm). The Smart One provides switch-selectable resolutions in both English (1000 lines per inch) and Metric (100 lines per cm).

Accuracy: English ±0.01 inch or Metric ±0.025 cm absolute. Optional accuracies available are English, ±0.005 inch ±½LSB and Metric ±0.013 cm ±½LSB absolute.

Repeatability: ±0.0005 inch.

Coordinate Origin: Lower left-hand corner. On The Smart One, the origin can be relocated to any point desired and assigned any value desired.

Repetition Rate: Variable 1–100 coordinate pairs per second. *Exception* - Units having RS232, baud rate will control repetition rate.

Output: *The Standard One* - provides either parallel binary or BCD. Optional outputs are in addition to parallel output. *Optional Output/Interface* - RS232, Dual Port RS232, Sequential, GPIB, Current Loop and others. *The Smart One* - output microprocessor-controlled for RS232, Dual Port RS232, GPIB. Parallel and other output interfaces on request.

Transducers: *Ballpoint Pen* - (with or without ink) provided with ±0.01 inch (±0.025 cm) accuracy units.
12-Button Cursor — provided with ±0.005 inch (±0.013 cm) accuracy units.

Power Requirements: 115V, 60Hz, 0.5A (max with LED displays). (100V, 230V, 50Hz also available.) *Back Lighting Units* - 115V, 60Hz:

Model	Watts	Model	Watts
611	42	640	240
614	56	648	310
622	100	660	480

Operating Modes: Remote, Point, Run, Track and Increment. On The Smart One, Menu Mode is added.

Controls: *Control Panel* - (located on digitizer surface assembly), Mode Select, Clear. Additional control on The Smart One — Menu Select. *Electronics Unit* - Power ON/OFF Switch, Repetition Rate Control. *Additional Controls on The Smart One* - Binary/BCD Select, English/Metric Select.

Indicators: *Control Panel* - (located on digitizer surface assembly). *Mode Selected* - (remote, point, run, track and increment). *Margin* - pen down and proximity. *On The Smart One* - Menu Mode is added. *Electronics Unit* - Power ON indicator.

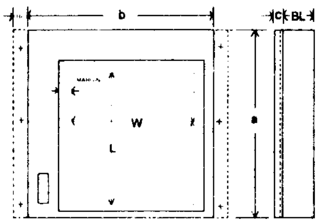
Additional Options: 10- and 32-character displays, Drafting Bases, OEM Configurations, Special Configurations.

Environmental:
Temperature Range: +15°C to 40°C operating.
Humidity: 0 to 95%, without condensation.
Note: Check these specified environments against other digitizers' environmental specifications.

Mechanical:
Cable lengths:
Surface to Electronics — 6 feet, 611, 614, 622.
Surface to Electronics — 10 feet, 640, 648, 660.
Transducer to Electronics — 8 feet, 611, 614, 622.
Transducer to Electronics — 12 feet, 640, 648, 660.
Output Cables — 6 feet.

Electronic Unit:
The Standard One:
11" x 9.5" x 5", 13 pounds.
The Smart One:
11" x 15" x 8", 16 pounds.

Digitizer Surfaces



Model	Active Surface Area			Surface Assembly Dimensions					Weight		
Number	L	W	Margin	a	b	c	RP*	BL**	Std. Solid	RP*	BL**
611	11	11	.75	17.75	17.75	.53	1	3.25	9	9	19
614	14	14	.75	20.75	20.75	.53	1	3.25	11	11	23
622	22	22	.75	29.25	29.25	.53	1	3.25	16½	16½	34
640	30	40	1.75	40.25	50.25	1.50	1.75	4	85	85	100
648	36	48	1.75	46.25	58.25	1.50	1.75	4	118	118	140
660	44	60	1.75	54.25	70.25	1.50	1.75	4	175	175	200

*RP — Rear Projected, Mounting Flange
**BL — Back Lighted, Light Housing

Dimensions In Inches
Weight In Pounds

Patents Pending

APPENDIX D

250000. FILE: CORO1 CHECK

34	35	69.000	17.000
37	469	69.000	17.250
38	903	69.000	17.500
40	1338	69.000	17.750
42	1772	69.000	18.000
457	1771	68.750	18.000
873	1770	68.500	18.000
1290	1769	68.250	18.000
1704	1770	68.000	18.000
2120	1770	67.750	18.000
2536	1771	67.500	18.000
2536	1337	67.500	17.750
2538	903	67.500	17.500
2541	468	67.500	17.250
2543	36	67.500	17.000
2125	34	67.750	17.000
1707	32	68.000	17.000
1289	32	68.250	17.000
870	32	68.500	17.000
452	34	68.750	17.000

250000. FILE: CORO2 CHECK

35	34	69.000	17.000
37	469	69.000	17.250
39	902	69.000	17.500
41	1337	69.000	17.750
43	1771	69.000	18.000
459	1771	68.750	18.000
874	1770	68.500	18.000
1300	1770	68.250	18.000
1706	1769	68.000	18.000
2121	1770	67.750	18.000
2535	1771	67.500	18.000
2536	1337	67.500	17.750
2538	903	67.500	17.500
2540	468	67.500	17.250
2543	34	67.500	17.000
2125	33	67.750	17.000
1707	32	68.000	17.000
1288	31	68.250	17.000
870	33	68.500	17.000
452	34	68.750	17.000

250000. FILE: CORO3 CHECK

35	34	69.000	17.000
37	467	69.000	17.250
40	902	69.000	17.500
42	1337	69.000	17.750
44	1770	69.000	18.000
460	1769	68.750	18.000
875	1768	68.500	18.000
1290	1768	68.250	18.000
1705	1769	68.000	18.000
2120	1769	67.750	18.000
2535	1771	67.500	18.000
2535	1336	67.500	17.750
2537	902	67.500	17.500
2539	469	67.500	17.250
2542	34	67.500	17.000
2125	33	67.750	17.000
1706	32	68.000	17.000
1288	31	68.250	17.000
871	32	68.500	17.000
453	33	68.750	17.000

Table 1. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Corocoro topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
34.667	34.333	69.000	69	0	0	17.000	17	0	0
37.000	468.333	69.000	69	0	0	17.250	17	15	0
39.000	902.333	69.000	69	0	0	17.500	17	30	0
41.000	1337.333	69.000	69	0	0	17.750	17	45	0
43.000	1771.000	69.000	69	0	0	18.000	18	0	0
458.667	1770.333	68.750	68	45	0	18.000	18	0	0
874.000	1769.333	68.500	68	30	0	18.000	18	0	0
1293.333	1769.000	68.250	68	15	0	18.000	18	0	0
1705.000	1769.333	68.000	68	0	0	18.000	18	0	0
2120.333	1769.667	67.750	67	45	0	18.000	18	0	0
2535.333	1771.000	67.500	67	30	0	18.000	18	0	0
2535.667	1336.667	67.500	67	30	0	17.750	17	45	0
2537.667	902.667	67.500	67	30	0	17.500	17	30	0
2540.000	468.333	67.500	67	30	0	17.250	17	15	0
2542.667	34.667	67.500	67	30	0	17.000	17	0	0
2125.000	33.333	67.750	67	45	0	17.000	17	0	0
1706.667	32.000	68.000	68	0	0	17.000	17	0	0
1288.333	31.333	68.250	68	15	0	17.000	17	0	0
870.333	32.333	68.500	68	30	0	17.000	17	0	0
452.333	33.667	68.750	68	45	0	17.000	17	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:
69.0232064800
-0.0005989539
-0.0000000004

Y COEFFICIENTS:
16.9810042921
0.0005740155
0.0000000010

Table 2. Averaged x and y values obtained from the three independent readings shown in Figure 1 and corresponding longitude and latitude for the Corocoro topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation for the regression coefficients also shown in this figure.

```
FILE: COR01     DIGIT    A1  LARS / PURDUE UNIVERSITY

  1     5     0     0
   453        433       457     1336     2121     1336     2123      467     1289      903
  2     17    0     0
   329        154       735      182      691      527      435     1216     1469      117
   908        875       980     1215     1671      312     1362     1563     2181      632
  2064        809      2238      802     1841     1427     1682     1756     2497     1070
  2373       1427      2512     1378
```

```
FILE: COR02     DIGIT    A1  LARS / PURDUE UNIVERSITY

  1     5     0     0
   454        476       457     1336     2121     1336     2123      468     1289      901
  2     17    0     0
   331        189       734      182      691      526      436     1216     1469      117
   910        874       980     1215     1671      311     1363     1562     2180      631
  2064        809      2238      802     1841     1426     1682     1755     2497     1071
  2373       1426      2512     1376
```

```
FILE: COR03     DIGIT    A1  LARS / PURDUE UNIVERSITY

  1     5     0     0
   455        462       458     1335     2121     1335     2123      467     1289      901
  2     17    0     0
   331        179       734      181      691      525      436     1217     1470      116
   910        873       981     1215     1671      310     1362     1561     2180      632
  2064        809      2238      801     1842     1425     1681     1754     2497     1071
  2373       1426      2512     1376
```

Table 3. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 17 control points of unknown longitude and latitude for the Corocoro topographic map.

```
FILE: COROS     DIGIT     A1  LARS / PURDUE UNIVERSITY

    1      5      0      0
  454.000    457.000    457.333   1335.667   2121.000   1335.667   2123.000    467.333
 1289.000    901.667
    2     17      0      0
  330.333    174.000    734.333    181.667    691.000    526.000    435.667   1216.333
 1469.333    116.667    909.333    874.000    980.333   1215.000   1671.000    311.000
 1362.333   1562.000   2180.333    631.667   2064.000    809.000   2238.000    801.667
 1841.333   1426.000   1681.667   1755.000   2497.000   1070.667   2373.000   1426.333
 2512.000   1376.667
```

Table 4. Averaged x and y values obtained from the three independent readings shown in Figure 3 of 5 test points of known longitude and latitude, and 17 control points.

```
FILE: CORCS    LONLAT   A1  LARS / PURDUE UNIVERSITY

     250000.
    1    5      0      0
 68.751100 17.243529 68.749193 17.749405 67.750839 17.749405 67.749638 17.249470
 68.250421 17.499353
    2   17      0      0
 68.825304 17.080912 68.583137 17.085316 68.609119 17.283201 68.762178 17.680614
 68.142191 17.047986 68.478193 17.483425 68.435608 17.679846 68.021122 17.159616
 68.206412 17.879952 67.715189 17.343973 67.785085 17.446009 67.680537 17.441789
 67.918836 17.801497 68.014717 17.991349 67.524866 17.596681 67.599403 17.801689
 67.515849 17.773046
```

Table 5. Calculated longitude and latitude (in degrees, decimals) for 5 test points of known longitude and latitude, and for 17 control points.

250000. FILE: COCHA1 CHECK

34	34	67.500	17.000
37	468	67.500	17.250
40	901	67.500	17.500
42	1333	67.500	17.750
43	1765	67.500	18.000
458	1764	67.250	18.000
874	1763	67.000	18.000
1290	1764	66.750	18.000
1705	1766	66.500	18.000
2122	1767	66.250	18.000
2537	1769	66.000	18.000
2539	1336	66.000	17.750
2541	902	66.000	17.500
2543	468	66.000	17.250
2546	35	66.000	17.000
2127	32	66.250	17.000
1709	31	66.500	17.000
1290	31	66.750	17.000
871	31	67.000	17.000
452	31	67.250	17.000

250000. FILE: COCHA2 CHECK

35	35	67.500	17.000
38	467	67.500	17.250
40	900	67.500	17.500
41	1333	67.500	17.750
43	1764	67.500	18.000
459	1764	67.250	18.000
874	1763	67.000	18.000
1290	1763	66.750	18.000
1706	1765	66.500	18.000
2121	1767	66.250	18.000
2536	1769	66.000	18.000
2538	1336	66.000	17.750
2540	902	66.000	17.500
2543	468	66.000	17.250
2545	35	66.000	17.000
2127	33	66.250	17.000
1709	32	66.500	17.000
1290	31	66.750	17.000
871	31	67.000	17.000
452	32	67.250	17.000

250000. FILE: COCHA3 CHECK

35	35	67.500	17.000
38	469	67.500	17.250
41	901	67.500	17.500
43	1334	67.500	17.750
44	1767	67.500	18.000
460	1766	67.250	18.000
876	1765	67.000	18.000
1291	1765	66.750	18.000
1707	1766	66.500	18.000
2123	1768	66.250	18.000
2538	1770	66.000	18.000
2539	1336	66.000	17.750
2541	902	66.000	17.500
2543	469	66.000	17.250
2546	35	66.000	17.000
2128	33	66.250	17.000
1710	33	66.500	17.000
1290	32	66.750	17.000
872	32	67.000	17.000
452	32	67.250	17.000

Table 6. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Cochabamba topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
34.667	34.667	67.500	67	30	0	17.000	17	0	0
37.667	468.000	67.500	67	30	0	17.250	17	15	0
40.333	900.667	67.500	67	30	0	17.500	17	30	0
42.000	1333.333	67.500	67	30	0	17.750	17	45	0
43.333	1765.333	67.500	67	30	0	18.000	18	0	0
459.000	1764.667	67.250	67	15	0	18.000	18	0	0
874.667	1763.667	67.000	67	0	0	18.000	18	0	0
1290.333	1764.000	66.750	66	45	0	18.000	18	0	0
1706.000	1765.667	66.500	66	30	0	18.000	18	0	0
2122.000	1767.333	66.250	66	15	0	18.000	18	0	0
2537.000	1769.333	66.000	66	0	0	18.000	18	0	0
2538.667	1336.000	66.000	66	0	0	17.750	17	45	0
2540.667	902.000	66.000	66	0	0	17.500	17	30	0
2543.000	468.333	66.000	66	0	0	17.250	17	15	0
2545.667	35.000	66.000	66	0	0	17.000	17	0	0
2127.333	32.667	66.250	66	15	0	17.000	17	0	0
1709.333	32.000	66.500	66	30	0	17.000	17	0	0
1290.000	31.333	66.750	66	45	0	17.000	17	0	0
871.333	31.333	67.000	67	0	0	17.000	17	0	0
452.000	31.667	67.250	67	15	0	17.000	17	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:

67.5235940611
-0.0005996216
0.0000000000

Y COEFFICIENTS:

16.9812520097
0.0005734970
0.0000000020

Table 7. Averaged x and y values obtained from the three independent readings shown in Figure 6 and corresponding longitude and latitude for the Cochabamba topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation of the regression coefficients also shown in this figure.

FILE: COCHA1   DIGIT   A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
454	479	458	1332	2123	1333	2125	465	1290	897
2	16	0	0						
314	191	466	340	324	1011	816	53	808	351
791	1179	677	1619	1342	66	1108	590	1020	1285
1725	64	1735	947	1651	1281	2490	234	2004	503
1905	1329								

FILE: COCHA2   DIGIT   A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
454	452	457	1331	2122	1334	2125	466	1289	897
2	16	0	0						
314	170	465	340	323	1010	817	54	806	352
791	1179	677	1618	1342	65	1107	591	1020	1284
1726	65	1735	946	1650	1281	2490	234	2003	503
1905	1330								

FILE: COCHA3   DIGIT   A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
455	465	459	1333	2124	1334	2127	467	1291	898
2	16	0	0						
315	180	466	341	324	1012	818	54	808	352
792	1181	679	1621	1343	66	1108	591	1022	1286
1727	66	1736	947	1652	1282	2490	234	2005	502
1907	1330								

Table 8. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 16 control points of unknowm longitude and latitude for the Cochabamba topographic map.

```
FILE: COCHAS   LONLAT   A1  LARS / PURDUE UNIVERSITY

     250000.
    1     5       0       0
 67.251172 17.248543 67.248973 17.748622 66.250714 17.749587 66.249115 17.248927
 66.750125 17.497446
    2    16       0       0
 67.335116 17.084736 67.244376 17.176659 67.329519 17.563058 67.033720 17.012036
 67.039517 17.183174 67.049110 17.660511 67.117262 17.915066 66.718749 17.018920
 66.859445 17.320681 66.911607 17.721427 66.488724 17.018538 66.483129 17.525917
 66.533689 17.719306 66.030696 17.115557 66.322056 17.270025 66.381009 17.747272
```

Table 9. Calculated longitudes and latitudes (in degrees, decimals) for 5 test points of known longitude and latitude, and for 16 control points.

FILE: COCHAS   DIGIT   A1 LARS / PURDUE UNIVERSITY

1 5	0 0						
454.333	465.333	458.000	1332.000	2123.000	1333.667	2125.667	466.000
1290.000	897.333						
2 16	0 0						
314.333	180.333	465.667	340.333	323.667	1011.000	817.000	53.667
807.333	351.667	791.333	1179.667	677.667	1619.333	1342.333	65.667
1107.667	590.667	1020.667	1285.000	1726.000	65.000	1735.333	946.667
1651.000	1281.333	2490.000	234.000	2004.000	502.667	1905.667	1329.667

Table 10. Averaged x and y values obtained from the three independent readings shown in Figure 8 of 5 test points of known longitude and latitude, and 16 control points.

250000. FILE: CORQ1 CHECK

35	34	69.000	18.000
38	468	69.000	18.250
40	903	69.000	18.500
43	1336	69.000	18.750
45	1769	69.000	19.000
458	1768	68.750	19.000
972	1767	68.500	19.000
1285	1766	68.250	19.000
1698	1766	68.000	19.000
2111	1767	67.750	19.000
2525	1768	67.500	19.000
2526	1335	67.500	18.750
2527	902	67.500	18.500
2528	468	67.500	18.250
2530	35	67.500	18.000
2115	33	67.750	18.000
1698	32	68.000	18.000
1283	32	68.250	18.000
867	33	68.500	18.000
451	32	68.750	18.000

250000. FILE: CORQ2 CHECK

34	35	69.000	18.000
37	469	69.000	18.250
40	902	69.000	18.500
43	1336	69.000	18.750
45	1769	69.000	19.000
459	1768	68.750	19.000
872	1766	68.500	19.000
1285	1765	68.250	19.000
1699	1765	68.000	19.000
2111	1766	67.750	19.000
2524	1767	67.500	19.000
2525	1334	67.500	18.750
2526	902	67.500	18.500
2527	467	67.500	18.250
2530	33	67.500	18.000
2114	33	67.750	18.000
1699	32	68.000	18.000
1292	33	68.250	18.000
866	34	68.500	18.000
451	34	68.750	18.000

250000. FILE: CORQ3 CHECK

34	36	69.000	18.000
37	469	69.000	18.250
40	902	69.000	18.500
43	1336	69.000	18.750
45	1769	69.000	19.000
459	1767	68.750	19.000
873	1765	68.500	19.000
1286	1765	68.250	19.000
1699	1764	68.000	19.000
2111	1765	67.750	19.000
2524	1766	67.500	19.000
2525	1333	67.500	18.750
2526	901	67.500	18.500
2527	467	67.500	18.250
2529	33	67.500	18.000
2114	32	67.750	18.000
1699	32	68.000	18.000
1282	33	68.250	18.000
866	34	68.500	18.000
450	34	68.750	18.000

Table 11. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Corque topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
34.333	35.000	69.000	69	0	0	18.000	18	0	0
37.333	468.667	69.000	69	0	0	18.250	18	15	0
40.000	902.333	69.000	69	0	0	18.500	18	30	0
43.000	1336.000	69.000	69	0	0	18.750	18	45	0
45.000	1769.000	69.000	69	0	0	19.000	19	0	0
458.667	1767.667	68.750	68	45	0	19.000	19	0	0
872.333	1766.000	68.500	68	30	0	19.000	19	0	0
1285.333	1765.333	68.250	68	15	0	19.000	19	0	0
1698.667	1765.000	68.000	68	0	0	19.000	19	0	0
2111.000	1766.000	67.750	67	45	0	19.000	19	0	0
2524.333	1767.000	67.500	67	30	0	19.000	19	0	0
2525.333	1334.000	67.500	67	30	0	18.750	18	45	0
2526.333	901.667	67.500	67	30	0	18.500	18	30	0
2527.333	467.333	67.500	67	30	0	18.250	18	15	0
2529.667	33.667	67.500	67	30	0	18.000	18	0	0
2114.333	32.667	67.750	67	45	0	18.000	18	0	0
1698.667	32.000	68.000	68	0	0	18.000	18	0	0
1285.667	32.667	68.250	68	15	0	18.000	18	0	0
866.333	33.667	68.500	68	30	0	18.000	18	0	0
450.667	33.333	68.750	68	45	0	18.000	18	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:
69.0239503706
-0.0006018245
-0.0000000005

Y COEFFICIENTS:
17.9809043720
0.0005740490
0.0000000016

Table 12. Averaged x and y values obtained from the three independent readings shown in Figure 11 and corresponding longitude and latitude for the Corque topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation of the regression coefficients also shown in this figure.

```
FILE: CORQ1     DIGIT     A1  LARS / PURDUE UNIVERSITY

  1     5      0      0
   452       468       456       1335       2112       1335       2114       467       1284       899
  2    14      0      0
   174      1155       205       1697        944        179       1038       868        767       949
   822      1076      1343        252       1262       1074       1351      1507       1842       231
  1625      1306      1479       1639       2355        723       2282      1446
```

```
FILE: CORQ2     DIGIT     A1  LARS / PURDUE UNIVERSITY

  1     5      0      0
   452       462       456       1335       2112       1334       2113       467       1284       900
  2    14      0      0
   174      1150       206       1697        944        181       1038       866        766       949
   822      1077      1343        251       1261       1073       1351      1506       1842       231
  1625      1306      1479       1638       2352        723       2282      1444
```

```
FILE: CORQ3     DIGIT     A1  LARS / PURDUE UNIVERSITY

  1     5      0      0
   452       462       456       1335       2112       1333       2113       466       1284       900
  2    14      0      0
   174      1151       207       1697        943        181       1037       866        765       949
   822      1077      1343        251       1261       1073       1351      1506       1842       230
  1625      1305      1479       1637       2352        722       2282      1444
```

Table 13. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 14 control points of unknown longitude and latitude for the Corque topographic map.

FILE: COROS DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0 0						
452.000	464.000	456.000	1335.000	2112.000	1334.000	2113.333	466.667
1284.000	899.667						
2 14	0 0						
174.000	1152.000	206.000	1697.000	943.667	180.333	1037.667	866.667
766.000	949.000	822.000	1076.667	1343.000	251.333	1261.333	1073.333
1351.000	1506.333	1842.000	230.667	1625.000	1305.667	1479.000	1638.000
2353.000	722.667	2282.000	1444.667				

Table 14. Averaged x and y values obtained from the three independent readings shown in Figure 13 of 5 test points of known longitude and latitude, and 14 control points.

```
FILE: CORQS     LONLAT   A1  LARS / PURDUE UNIVERSITY

    250000.
   1    5      0      0
 68.751817 18.247607 68.749408 18.750104 67.750526 18.749526 67.749721 18.249142
 68.250331 18.498649
   2   14      0      0
 68.919217 18.644327 68.899952 18.959662 68.455555 18.084476 68.398885 18.479612
 68.562641 18.527114 68.528891 18.600814 68.214741 18.125283 68.264004 18.598889
 68.209915 18.849235 67.913566 18.113403 68.044562 18.733142 68.132689 18.925479
 67.604914 18.396584 67.647819 18.813545
```

Table 15. Calculated longitudes and latitudes (in degrees, decimals) for 5 test points of known longitude and latitude, and for 14 control points.

250000.

FILE: UNCIA1 CHECK

35	34	67.500	18.000
38	469	67.500	18.250
40	905	67.500	18.500
43	1339	67.500	18.750
45	1774	67.500	19.000
457	1772	67.250	19.000
870	1771	67.000	19.000
1283	1771	66.750	19.000
1696	1771	66.500	19.000
2109	1772	66.250	19.000
2521	1774	66.000	19.000
2523	1339	66.000	18.750
2526	905	66.000	18.500
2528	469	66.000	18.250
2532	35	66.000	18.000
2115	33	66.250	18.000
1698	32	66.500	18.000
1282	32	66.750	18.000
866	33	67.000	18.000
450	33	67.250	18.000

250000.

FILE: UNCIA2 CHECK

35	34	67.500	18.000
38	469	67.500	18.250
40	905	67.500	18.500
43	1338	67.500	18.750
45	1773	67.500	19.000
457	1773	67.250	19.000
870	1771	67.000	19.000
1283	1771	66.750	19.000
1695	1771	66.500	19.000
2109	1772	66.250	19.000
2521	1774	66.000	19.000
2523	1339	66.000	18.750
2526	905	66.000	18.500
2528	469	66.000	18.250
2532	35	66.000	18.000
2115	32	66.250	18.000
1698	32	66.500	18.000
1232	32	66.750	18.000
866	33	67.000	18.000
450	33	67.250	18.000

250000.

FILE: UNCIA3 CHECK

35	35	67.500	18.000
38	468	67.500	18.250
40	904	67.500	18.500
42	1338	67.500	18.750
43	1772	67.500	19.000
456	1771	67.250	19.000
869	1770	67.000	19.000
1283	1770	66.750	19.000
1695	1771	66.500	19.000
2107	1772	66.250	19.000
2520	1774	66.000	19.000
2522	1339	66.000	18.750
2525	905	66.000	18.500
2528	469	66.000	18.250
2531	36	66.000	18.000
2115	34	66.250	18.000
1698	33	66.500	18.000
1232	32	66.750	18.000
867	32	67.000	18.000
449	33	67.250	18.000

Table 16. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Uncia topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
35.000	34.333	67.500	67	30	0	18.000	18	0	0
38.000	468.667	67.500	67	30	0	18.250	18	15	0
40.000	904.667	67.500	67	30	0	18.500	18	30	0
42.667	1338.333	67.500	67	30	0	18.750	18	45	0
44.333	1773.000	67.500	67	30	0	19.000	19	0	0
456.667	1772.000	67.250	67	15	0	19.000	19	0	0
869.667	1770.667	67.000	67	0	0	19.000	19	0	0
1283.000	1770.667	66.750	66	45	0	19.000	19	0	0
1695.333	1771.000	66.500	66	30	0	19.000	19	0	0
2108.333	1772.000	66.250	66	15	0	19.000	19	0	0
2520.667	1774.000	66.000	66	0	0	19.000	19	0	0
2522.667	1339.000	66.000	66	0	0	18.750	18	45	0
2525.667	905.000	66.000	66	0	0	18.500	18	30	0
2528.000	469.000	66.000	66	0	0	18.250	18	15	0
2531.667	35.333	66.000	66	0	0	18.000	18	0	0
2115.000	33.000	66.250	66	15	0	18.000	18	0	0
1698.000	32.333	66.500	66	30	0	18.000	18	0	0
1282.000	32.000	66.750	66	45	0	18.000	18	0	0
865.333	32.667	67.000	67	0	0	18.000	18	0	0
449.667	33.000	67.250	67	15	0	18.000	18	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:
67.5240446656
-0.0006039120
0.0000000002

Y COEFFICIENTS:
17.9809995653
0.0005724984
0.0000000015

Table 17. Averaged x and y values obtained from the three independent readings shown in Figure 16 and corresponding longitude and latitude for the Uncia topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation of the regression coefficients also shown in this figure.

FILE: UNCIA1 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
452	476	455	1338	2110	1338	2113	468	1282	903
2 11	0	0							
1070	313	956	658	641	1582	1349	158	1281	1051
1107	1488	2058	301	1557	1438	2049	985	2427	941
1986	1575								

FILE: UNCIA2 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
452	475	455	1338	2110	1338	2113	468	1282	903
2 11	0	0							
1070	313	955	658	641	1582	1349	159	1282	1051
1107	1489	2058	301	1556	1438	2049	985	2427	941
1986	1575								

FILE: UNCIA3 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
451	469	454	1337	2109	1338	2113	467	1282	902
2 11	0	0							
1071	301	954	657	640	1582	1348	159	1281	1053
1105	1489	2058	301	1555	1438	2047	984	2426	942
1985	1575								

Table 18. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 11 control points of unknown longitude and latitude for the Uncia topographic map.

```
FILE: UNCIAS   DIGIT    A1  LARS / PURDUE UNIVERSITY

     1      5       0      0
   451.667      473.333     454.667    1337.667    2109.667    1338.000    2113.000     467.667
  1282.000      902.667
     2     11       0      0
  1070.333      309.000     955.000     657.667     640.667    1582.000    1348.667     158.667
  1281.333     1051.667    1106.333    1488.667    2058.000     301.000    1556.000    1438.000
  2048.333      984.667    2426.667     941.333    1985.667    1575.000
```

Table 19. Averaged x and y values obtained from the three independent readings shown in Figure 18 of 5 test points of known longitude and latitude, and 11 control points.

```
FILE: UNCIAS   LONLAT   A1  LARS / PURDUE UNIVERSITY

     250000.
    1     5       0       C
 67.251321 18.252309 67.249510 18.749421 66.250942 18.749612 66.248932 18.249057
 66.750180 18.498963
    2    11       0       C
 66.877902 18.158041 66.947503 18.358143 67.137226 18.890341 66.709957 18.071873
 66.750583 18.584690 66.856178 18.836490 66.282098 18.153454 66.584875 18.807267
 66.287928 18.546133 66.059809 18.521203 66.325719 18.886301
```

Table 20. Calculated longitudes and latitudes (in degrees, decimals) for 5 test points of known longitude and latitude, and for 11 control points.

250000. FILE: SALIN1 CHECK

35	34	69.000	19.000
38	469	69.000	19.250
41	902	69.000	19.500
44	1338	69.000	19.750
46	1771	69.000	20.000
456	1770	68.750	20.000
866	1769	68.500	20.000
1277	1768	68.250	20.000
1687	1769	68.000	20.000
2096	1769	67.750	20.000
2505	1770	67.500	20.000
2506	1336	67.500	19.750
2508	903	67.500	19.500
2510	467	67.500	19.250
2513	34	67.500	19.000
2099	31	67.750	19.000
1688	31	68.000	19.000
1275	31	68.250	19.000
862	32	68.500	19.000
448	33	68.750	19.000

250000. FILE: SALIN2 CHECK

35	36	69.000	19.000
38	469	69.000	19.250
40	903	69.000	19.500
43	1338	69.000	19.750
46	1770	69.000	20.000
454	1770	68.750	20.000
865	1769	68.500	20.000
1274	1768	68.250	20.000
1684	1769	68.000	20.000
2094	1769	67.750	20.000
2503	1771	67.500	20.000
2504	1338	67.500	19.750
2506	903	67.500	19.500
2508	468	67.500	19.250
2511	36	67.500	19.000
2098	34	67.750	19.000
1686	33	68.000	19.000
1273	33	68.250	19.000
860	33	68.500	19.000
448	33	68.750	19.000

250000. FILE: SALIN3 CHECK

35	34	69.000	19.000
38	467	69.000	19.250
40	902	69.000	19.500
43	1336	69.000	19.750
45	1770	69.000	20.000
454	1768	68.750	20.000
864	1758	68.500	20.000
1274	1767	68.250	20.000
1683	1768	68.000	20.000
2092	1768	67.750	20.000
2501	1770	67.500	20.000
2503	1337	67.500	19.750
2505	901	67.500	19.500
2508	466	67.500	19.250
2510	35	67.500	19.000
2098	33	67.750	19.000
1685	32	68.000	19.000
1273	32	68.250	19.000
860	32	68.500	19.000
448	32	68.750	19.000

Table 21. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Salinas de Garci Mendoza topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
35.000	34.667	69.000	69	0	0	19.000	19	0	0
38.000	468.333	69.000	69	0	0	19.250	19	15	0
40.333	902.333	69.000	69	0	0	19.500	19	30	0
43.333	1337.333	69.000	69	0	0	19.750	19	45	0
45.667	1770.333	69.000	69	0	0	20.000	20	0	0
454.667	1769.333	68.750	68	45	0	20.000	20	0	0
865.000	1768.667	68.500	68	30	0	20.000	20	0	0
1275.000	1767.667	68.250	68	15	0	20.000	20	0	0
1684.667	1768.667	68.000	68	0	0	20.000	20	0	0
2094.000	1768.667	67.750	67	45	0	20.000	20	0	0
2503.000	1770.333	67.500	67	30	0	20.000	20	0	0
2504.333	1337.000	67.500	67	30	0	19.750	19	45	0
2506.333	902.333	67.500	67	30	0	19.500	19	30	0
2508.667	467.000	67.500	67	30	0	19.250	19	15	0
2511.333	35.000	67.500	67	30	0	19.000	19	0	0
2098.333	32.667	67.750	67	45	0	19.000	19	0	0
1686.333	32.000	68.000	68	0	0	19.000	19	0	0
1273.667	32.000	68.250	68	15	0	19.000	19	0	0
860.667	32.333	68.500	68	30	0	19.000	19	0	0
443.000	32.667	68.750	68	45	0	19.000	19	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:
69.0244924091
-0.0006074885
-0.0000000003

Y COEFFICIENTS:
18.9810846616
0.0005738468
0.0000000012

Table 22. Averaged x and y values obtained from the three independent readings shown in Figure 21 and corresponding longitude and latitude for the Salinas de Garci Mendoza topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation of the regression coefficients also shown in this figure.

FILE: SALIN1 DIGIT A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
450	474	454	1335	2097	1340	2098	467	1276	903
2	10	0	0						
826	270	1116	670	1966	419	1381	1270	1070	1721
1635	1118	1737	1255	2491	693	2373	1302	2449	1492

FILE: SALIN2 DIGIT A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
449	467	452	1336	2095	1342	2097	468	1274	902
2	10	0	0						
824	260	1114	671	1984	420	1380	1270	1068	1721
1633	1118	1733	1255	2490	694	2371	1304	2446	1494

FILE: SALIN3 DIGIT A1 LARS / PURDUE UNIVERSITY

1	5	0	0						
449	470	452	1334	2093	1339	2096	466	1273	901
2	10	0	0						
825	267	1114	669	1983	419	1378	1269	1068	1719
1632	1117	1732	1254	2488	693	2370	1302	2445	1492

Table 23. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 10 control points of unknown longitude and latitude for the Salinas de Garci Mendoza topographic map.

```
FILE: SALINS   DIGIT    A1  LAFS / PURDUE UNIVERSITY

      1       5       0       0
   449.333   470.333   452.667  1335.000  2095.000  1340.333  2097.000   467.000
  1274.333   902.000
      2      10       0       0
   825.000   265.667  1114.667   670.000  1984.333   419.333  1379.667  1269.667
  1068.667  1720.333  1633.333  1117.667  1734.000  1254.667  2489.667   693.333
  2371.333  1302.667  2446.667  1492.667
```

Table 24. Averaged x and y values obtained from the three independent readings shown in Figure 23 of 5 test points of known longitude and latitude, and 10 control points.

```
FILE: SALINS   LONLAT   A1  LARS / PURDUE UNIVERSITY

     250000.
    1    5     0     0
 68.751475 19.251242 68.749449 19.749255 67.750663 19.752332 67.749446 19.249326
 68.249928 19.499646
    2   10     0     0
 68.523137 19.133619 68.347022 19.366087 67.818009 19.221923 68.185866 19.711564
 68.374993 19.971754 68.031568 19.623915 67.970326 19.702912 67.510437 19.379514
 67.582473 19.730601 67.536614 19.840253
```

Table 25. Calculated longitudes and latitudes (in degrees, decimals) for 5 test points of known longitude and latitude, and for 10 control points.

250000. FILE: MULA1 CHECK

35	35	67.500	19.000
38	469	67.500	19.250
40	903	67.500	19.500
41	1337	67.500	19.750
44	1770	67.500	20.000
454	1768	67.250	20.000
865	1766	67.000	20.000
1277	1767	66.750	20.000
1687	1767	66.500	20.000
2098	1768	66.250	20.000
2508	1771	66.000	20.000
2511	1337	66.000	19.750
2513	903	66.000	19.500
2515	469	66.000	19.250
2518	34	66.000	19.000
2104	32	66.250	19.000
1690	32	66.500	19.000
1276	33	66.750	19.000
862	32	67.000	19.000
448	33	67.250	19.000

250000. FILE: MULA2 CHECK

35	35	67.500	19.000
37	468	67.500	19.250
39	902	67.500	19.500
40	1336	67.500	19.750
42	1768	67.500	20.000
452	1767	67.250	20.000
863	1766	67.000	20.000
1275	1766	66.750	20.000
1686	1767	66.500	20.000
2096	1769	66.250	20.000
2507	1771	66.000	20.000
2510	1338	66.000	19.750
2512	903	66.000	19.500
2515	470	66.000	19.250
2519	35	66.000	19.000
2103	34	66.250	19.000
1690	32	66.500	19.000
1275	32	66.750	19.000
861	32	67.000	19.000
447	34	67.250	19.000

250000. FILE: MULA3 CHECK

35	34	67.500	19.000
38	468	67.500	19.250
40	903	67.500	19.500
41	1336	67.500	19.750
43	1769	67.500	20.000
453	1767	67.250	20.000
854	1766	67.000	20.000
1277	1767	66.750	20.000
1687	1767	66.500	20.000
2097	1768	66.250	20.000
2509	1770	66.000	20.000
2511	1338	66.000	19.750
2513	903	66.000	19.500
2515	469	66.000	19.250
2518	35	66.000	19.000
2104	32	66.250	19.000
1689	32	66.500	19.000
1276	32	66.750	19.000
863	32	67.000	19.000
448	32	67.250	19.000

Table 26. Three independent x and y readings from the table digitizer and corresponding known longitude and latitude for the Rio Mulatos topographic map at a scale of 1:250,000.

*** CHECKPOINTS USED ***

X PNT	Y PNT	LONG.	DEG	MIN	SEC	LAT.	DEG	MIN	SEC
35.000	34.667	67.500	67	30	0	19.000	19	0	0
37.667	468.333	67.500	67	30	0	19.250	19	15	0
39.667	902.667	67.500	67	30	0	19.500	19	30	0
40.667	1336.333	67.500	67	30	0	19.750	19	45	0
43.000	1769.000	67.500	67	30	0	20.000	20	0	0
453.000	1767.333	67.250	67	15	0	20.000	20	0	0
864.000	1766.000	67.000	67	0	0	20.000	20	0	0
1276.333	1766.667	66.750	66	45	0	20.000	20	0	0
1686.667	1767.000	66.500	66	30	0	20.000	20	0	0
2097.000	1768.333	66.250	66	15	0	20.000	20	0	0
2508.000	1770.667	66.000	66	0	0	20.000	20	0	0
2510.667	1337.667	66.000	66	0	0	19.750	19	45	0
2512.667	903.000	66.000	66	0	0	19.500	19	30	0
2515.000	469.333	66.000	66	0	0	19.250	19	15	0
2518.000	34.667	66.000	66	0	0	19.000	19	0	0
2103.667	32.667	66.250	66	15	0	19.000	19	0	0
1689.667	32.000	66.500	66	30	0	19.000	19	0	0
1275.667	32.333	66.750	66	45	0	19.000	19	0	0
862.000	32.000	67.000	67	0	0	19.000	19	0	0
447.667	33.000	67.250	67	15	0	19.000	19	0	0

THE FOLLOWING COEFFICIENTS WERE USED:

X COEFFICIENTS:
67.5236598676
-0.0006067546
0.0000000002

Y COEFFICIENTS:
18.9810949283
0.0005724964
0.0000000022

Table 27. Averaged x and y values obtained from the three independent readings shown in Figure 26 and corresponding longitude and latitude for the Rio Mulatos topographic map at a scale of 1:250,000. These 20 readings were utilized for the computation of the regression coefficients also shown in this figure.

FILE: MULA1 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
450	471	452	1335	2099	1334	2102	467	1276	899
2 12	0	0							
654	454	842	481	971	939	1427	274	1326	836
2202	123	1919	661	2259	590	64	943	882	1581
1362	1307	2010	1008						

FILE: MULA2 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
449	469	451	1334	2098	1334	2101	468	1276	900
2 12	0	0							
653	453	840	481	970	939	1426	273	1325	836
2202	122	1918	662	2257	591	64	944	881	1581
1361	1307	2009	1009						

FILE: MULA3 DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0	0							
450	453	452	1334	2099	1334	2102	466	1276	900
2 12	0	0							
655	432	842	480	971	938	1427	274	1325	836
2202	122	1919	660	2259	590	64	942	882	1581
1361	1307	2010	1008						

Table 28. Three independent sets of x and y readings from the table digitizer of 5 test points of known longitude and latitude, and 12 control points of unknown longitude and latitude for the Rio Mulatos topographic map.

FILE: MULAS DIGIT A1 LARS / PURDUE UNIVERSITY

1 5	0 0						
449.667	464.333	451.667	1334.333	2098.667	1334.000	2101.667	467.000
1276.000	899.667						
2 12	0 0						
654.000	446.333	841.333	480.667	970.667	938.667	1426.667	273.667
1325.333	836.000	2202.000	122.333	1918.667	661.000	2258.333	590.333
64.000	943.000	881.667	1561.000	1361.333	1307.000	2009.667	1008.333

Table 29. Averaged x and y values obtained from the three independent readings shown in Figure 28 of 5 test points of known longitude and latitude, and 12 control points.

```
FILE: MULAS     LONLAT    A1   LARS / PURDUE UNIVERSITY

      250000.
     1     5      0      0
  67.250857 19.247391 67.249644 19.748851 66.251036 19.748659 66.249218 19.248923
  66.749719 19.497904
     2    12      0      0
  67.126915 19.237050 67.013298 19.256775 66.934864 19.520386 66.658371 19.137930
  66.719808 19.461215 66.188414 19.051163 66.360129 19.360461 66.154277 19.319813
  67.484828 19.522885 66.988837 19.891625 66.697981 19.733047 66.304975 19.560564
```

Table 30. Calculated longitudes and latitudes (in degrees, decimals) for 5 test points of known longitude and latitude, and for 12 control points.

APPENDIX E

Glossary of Terms

Aerial Photograph — Generally, any photograph of the terrain taken with a camera mounted in an aircraft.

Alphanumeric Data — Data represented by letters of the alphabet and numbers.

Analysis — Performing computations on previously obtained data.

Attribute — Characteristic of a site or phenomenon.

Base Map — Map used as a primary source for compilation or as a framework on which new detail is printed. The term "base map" may be applied to topographic maps that are used in the construction of other types of maps by adding particular data.

Batch Processing — A user prepares a request to the computer (frequently in the form of key-punched cards) and submits the request to a computing center; the results (output) are produced and available for the user at a later time. (Compare to **Interactive Processing.**)

Cartography — Science and art of making maps and charts. The term may be taken broadly as comprising all the steps needed to produce a map.

Cathode Ray Tube (CRT) — Television screen for displaying electronic images.

Cell System (Grid System) — A scheme for storing data in a computer system in which a square or rectangular grid resembling a checkerboard is superimposed over the area of interest. Data within each square or rectangle may then be aggregated according to each type of variable. (Also referred to as raster data.)

Color Infrared Film — Vegetation generally reflects a lot of energy in infrared wavelengths not visible to the human eye. Color infrared film can record this energy because it is sensitized to green, red and near infrared instead of blue, green and red wavelengths of conventional color films; on this film healthy vegetation is bright red or pink, and dead or dying vegetation is a shade of green. Originally developed for camouflage detection. Synonym: False color film.

Composite Mapping — Ability to combine the characteristics of two or more maps to generate a summary composite map.

Computer — An electronic machine capable of processing numbers and letters of the alphabet for many different purposes.

Computer Program — A sequence of instructions that cause a computer to complete a desired task.

Coordinate System — Any one of a number of systems used to reference point, line and area information by defining its geographic location (e.g. State Plane Coordinate System, Universal Transverse Mercator).

Coordinates — Linear and (or) angular quantities that designate the position of a point in relation to a given reference frame.

CRT — See **Cathode Ray Tube.**

Data — A general term used to denote any or all facts in the form of numbers, letters, text or symbols. Raw facts or statistics which alone have little or no meaning, but as a group allow some meaningful relationships to be drawn.

Data Base	A large collection of data containing relationships between various data items. Synonym: Data bank.
Data Encoding/Data Entry	The process of converting data to machine readable form. Encoding is a general term referring to a manual or a machine-aided process.
Digital Image	Image having numeric values representing gray tones. Each numeric value represents a different gray tone.
Digital Image Processing	Computer manipulation of the digital values for gray tones of an image.
Digital Value	Data are said to have digital values when they can be represented numerically. Necessary for computation within a computer.
Digitize	The process of using the digitizer to produce computerized representations of maps and aerial photography.
Digitizer	1) An instrument (typically a drafting-type table) that transforms maps into computerized form. The digitizer collects data in the form of X and Y coordinate points from a source, usually a base map. Computer programs can then use the data to calculate areas, produce plotted maps, etc. 2) One who operates a digitizing machine.
DIME	Acronym for "Dual Independent Map Encoding"; a method of representing map features numerically for processing by a computer. The DIME File was designed and implemented by the Bureau of Census for use in gathering data for the decennial census.
Disk Storage	A rotating plate having magnetized surfaces on which data may be stored. (Alternate spelling: Disc.)
Encoding	See **Data Encoding/Data Entry.**
File	An organized collection of associated data directed toward some purpose, usually associated with a physical device such as a tape, disk, filing cabinet, etc.
Geocode	The process of attaching a geographic reference to a phenomenon, such as assigning a latitude-longitude to a water well site.
Geographic Coordinates	A spherical coordinate system for defining the position of points on the Earth expressed in terms of a regular coordinate system.
Geographic Information System	An information system that can *input, manipulate* and *analyze* geographically referenced data in order to support the decision-making processes of an organization.
Geographic Reference	Explicit two- and three-dimensional locators of a phenomenon, such as assigning the latitude-longitude to a water well site.
Graphic CRT Terminal	A cathode ray tube usually used as a terminal to a computer which has the capability to draw lines, points, polygons, graphs or charts on a screen.
Graticule	The network of lines of latitude and longitude upon which a map is drawn.
Gray-Tone Map	Line printer and electrostatic plotter maps portraying various features or attributes as different shades of grayness from white to black. Electrostatic plotters use an on/off dot pattern to produce up to 63 gray-scale patterns although only about 16 patterns can be easily differentiated with the eye. The maps produced from either device are known as gray-tone maps, where each tone of blackness corresponds to a different data type on the map.

Grid	A network of uniformly spaced horizontal and perpendicular lines (as for locating something on a map).
Hard Copy	Any computer output that is printed on paper, rather than shown on a CRT screen, for example.
Hardware	The physical, electronic and mechanical equipment or devices forming a computer and associated peripheral equipment. (Contrast with **Software**.)
Imagery	The visual representation of energy recorded by remote sensing instruments. Representation or reproduction of objects and/or phenomena as sensed or detected by cameras, scanners, radar, etc. Recording may be on photographic emulsion or on magnetic tape for subsequent conversion and display on a cathode ray tube.
Information	Organization of data so that they are in a form useable for decision-making.
Information Network	The interconnecting of a geographically dispersed group of libraries and information centers, through telecommunications, for the purpose of sharing their total information resources among more people.
Information System	Information or data resources joined together in both a formal and informal manner to support the decision-making process of an organization.
Infrared	Radiant energy with wavelengths somewhat longer than visible energy.
Input	The process of entering information into a computer.
Interactive Processing	A type of man-machine interface where a user types commands to a computer via a terminal, gets information back from the computer in a short time, and generally "converses" with the computer. (Compare to **Batch Processing.**)
Interface	The junction between the components of an information system.
Interpretation	See **Photographic Interpretation.**
Keypunched Card	See **Punched Card.**
Land Cover	Cultural objects and natural and cultivated vegetation occupying the landscape that can be grouped or classified and subsequently mapped using remotely sensed imagery.
Land Use	Utilization of land. A land use map prepared from aerial photography employs categories such as pasture, wasteland and unimproved land, all of which might conceivably fit into a grassland category of a land cover map.
Landsat	An unmanned Earth-orbiting NASA satellite that transmits images to Earth receiving stations (formerly called ERTS—Earth Resources Technology Satellite).
Latitude	Angular distance, in degrees, minutes, and seconds, of a point north or south of the Equator.
Line Printer	A computer hardware output device that produces tables, reports or maps by a series of alphanumeric characters printed on sheets of paper.
Longitude	Angular distance, in degrees, minutes and seconds, of a point east or west of the Greenwich meridian.
Machine Readable (Machine Processable)	Information in a form such as punched cards or magnetic tape that can be processed directly by computers and other machines.

Magnetic Disk (Disc)	An information storage media on which information is recorded on a magnetizable surface of a rotating disk, with associated reading and writing heads which are mounted on movable arms.
Magnetic Tape	A long strip of mylar, plastic-coated with ferrous oxide, on which information may be stored or read.
Map Digitization	Conversion of map data from graphic to digital form.
Memory	A device that stores information for later recall.
Minicomputer	A modern computer which performs similar functions faster and in a smaller space than earlier computers.
NASA	National Aeronautics and Space Administration.
Off-Line	In batch processing, the jobs for the computer are said to be prepared "off-line" because the user is not directly connected with the computer's central processing unit. A type of operation which is not directly connected to a central processor unit.
Photographic Interpretation	The act of examining photographic images for the purpose of identifying objects and judging their significance. Photo interpretation, image interpretation, and image analysis are other widely used synonyms.
Picture Element	Unit of resolution on Landsat imagery. One picture element on Landsats 1, 2, and 3 data corresponds to a ground area measuring approximately 57 by 79 meters. Synonym: Pixel.
Pixel	A contraction of "picture element."
Plot	A spatial representation of data generated by an output device such as a digital plotter or line printer.
Plotter	A computer hardware output device that produces single or multi-colored pen plots of maps, charts or figures which are stored in a computer.
Point Data	Data that can be associated with a single geographic location (for example, an address).
Polygon System	A system of organizing data in a computer where an area on a map or aerial photograph is represented by a string of three or more coordinate pairs.
Processing	Refers to computer operations or handling of data in a sequence of logical operations.
Program	More commonly referred to as a "computer program"; the complete plan for the solution of a problem. Specifically, the complete sequence of computer instructions necessary to solve a problem.
Public Land System	Public lands are subdivided by a rectangular system of surveys established and regulated by the Bureau of Land Management. The standard format for subdivision is by townships measuring 6 miles on a side. Townships are further subdivided into 36 numbered sections of 1 square mile (640 acres) each.
Punched Card	A stiff paper card of exact dimensions into which holes are punched to represent information. Subsequently, the information can be sensed and processed by mechanical, electrical or optical machines.
Quadrangle	Four-sided area, bounded by parallels of latitude and meridians of longitude, used as an area unit in mapping (dimensions are not necessarily the same in both directions).

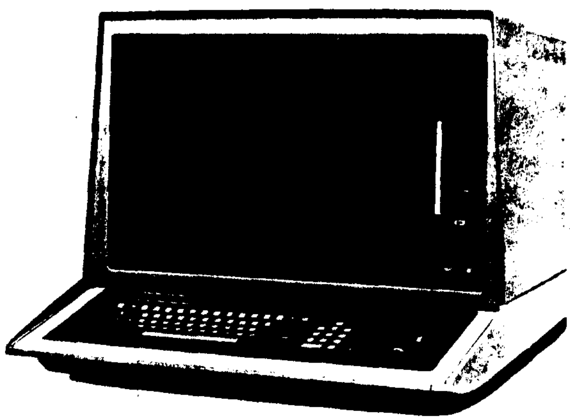
Remote Sensing	Perceiving information or data about certain objects or conditions from a distance without physical contact. Examples are the human eye, a camera which might be hand-held or airborne, or a satellite sensor.
Report	A tabular representation or product produced by the computer, usually output to a line printer, and displaying data in an organized and readable (and usually summary) form.
Scale	Relationship which exists between a distance on a map or photograph and the corresponding distance on the Earth. It may be expressed as an equivalence (e.g. 1" = 16 miles); as a fraction or ratio (e.g. 1:24,000); or as a bar graph subdivided to show distance which each of its parts represents on the Earth.
Software	A set of instructions that tell the computer (hardware) what to do.
Soil Map	Map that shows the constitution, structure, and texture of the soil and identifies ongoing erosion.
Spatial	Refers to the location of, proximity to, or orientation of objects with respect to one another.
Spatial Data	Facts about the real world organized geographically. Discrete symbols (numbers, letters, or special characters) used to describe some entity; these data are organized according to the location of that entity in the three-dimensional world.
Spatial Information System	See **Geographic Information System.**
State Plane Coordinate System	Coordinate systems established by the U.S. Coast and Geodetic Survey (now the National Ocean Survey), one for each state, for use in defining positions of geodetic stations in terms of plane rectangular (x,y) coordinates.
Survey	Orderly process of determining data relating to any physical or chemical characteristics of the Earth. The associated data obtained in a survey.
System	An assembly of procedures, processes, methods, routines or techniques united by some form of regulated interaction to create an organized whole.
Telecommunications	The process of transmitting data between geographically separate pieces of electronic equipment.
Teletype	A piece of equipment capable of sending and receiving information that is typed at one location and printed at another.
Terminal (Computer Terminal)	A remote communications hookup to a computer that may be used for either input or output. A general term used to denote the various hardware devices which are used to communicate with computers.
Topographic Map	Map that represents the horizontal and vertical positions of the features represented.
Topography	Configuration (relief) of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines.
Universal Transverse Mercator (UTM) Grid	Military grid system based on the transverse Mercator projection, applied to maps of the Earth's surface extending from the Equator to 84° N. and 80° S. latitudes.
Watershed	A region or area draining ultimately to a particular watercourse or body of water.

APPENDIX F

4054 TEKTRONIX

19" screen desktop computing system with enhanced graphics and powerful BASIC.

Graphic Computing System



Unequaled graphics and powerful, fast computing in an integrated desktop computer. The 4054 is the only desktop computer that combines easy-to-learn, extended BASIC with the unique features of a large-screen, high resolution Tektronix display. For rapid calculation, the 4054 has a fast processor with microcoded floating point. The state-of-the-art graphics capabilities of the 4054 provide for demand hard copy of any combination of text and high-density graphics (with optional hard copy unit). Fast processing coupled with simultaneous text and graphics display offer an excellent fit for many sophisticated graphics environments. In addition, the 4054's memory capacity can be expanded from a standard 32K bytes, up to 64K bytes. The 4054 comes standard with a GPIB interface conforming to IEEE Standard 488-1975. Through this interface, a variety of printers, plotters, graphics tablets and/or mass storage units may be connected, offering a powerful solution for most application requirements.

The 4054 features software compatibility with the rest of the 4050 Series of desktop computers. Our 4051 set the standard for high performance, affordable desktop computing. The 4052 utilizes a new processor and offers a larger memory capacity. Programs developed on the 4051 and 4052 will operate on the 4054, giving 4054 users access to a wealth of PLOT 50 software, already written and debugged, thus reducing program development costs often associated with new systems.

The 4050 Series has a long list of proven peripheral products. GPIB (General Purpose Interface Bus) and RS232-C interfacing coupled with easy-to-program BASIC I/O commands allow considerable versatility in designing your own system. Furthermore, additional peripherals can be readily integrated as your application needs change or grow.

Superior Graphic and Alphanumeric Display. The 4054, with 4096 (x) by 4096 (y) resolution — 13 million addressable points — has all the graphics capability you will need for even the most complex display. With ASCII stroke-generated characters programmable in four sizes and eight fonts, the 4054 has the tools to alphanumerically dress up your output to suit any professional requirement, including previewing of 132 column line printer output.

For your graphing needs there are 36 distinct dot-dashed patterns, selectable under program control, providing for maximum effect of represented data. For interactivity the 4054 has a thumbwheel driven, true cross-hair cursor. All of these features are implemented using the extended BASIC of the 4054.

Friendly extended BASIC provides the simplicity desired by the beginner together with the flexibility and power required by the experienced programmer. Device independent keywords make program and data input/output operations easy in either binary or ASCII formats. Fast, built-in BASIC functions such as SINE, LOG, SQR, etc. plus a complete set of matrix functions provide powerful computation at your fingertips. Add easy-to-use BASIC graphic commands such as MOVE, DRAW, etc. and it is easy to see the potential uses of the 4054.

Data Communications. With the Data Communications Interface (Option 1) the 4054 can communicate asynchronously with a host computer at rates up to 9600 Baud. In terminal mode, the 4054 emulates our popular 4014-1 Graphic Display Terminal, and allows direct data transfer between the built-in cartridge tape drive and host computer.

Excellent Product Quality. The 4054, like all Tektronix products, is rigorously tested at all levels of manufacturing. The benefits of this concentrated effort to our customers are product excellence and reliability. To continue this commitment to product excellence after the sale, Tektronix offers a full one year warranty and a worldwide network of service and technical assistance.

Central Processing Unit

Type: Bit-slice technology.

User memory workspace:

Standard	32K bytes
Opt. 24	64K bytes (56K user)

Programming Language: BASIC with numerous extensions.

Dynamic Range: $\pm 10^{-308}$ to $\pm 10^{+308}$

Numeric Accuracy: 14 decimal digits with 12 displayed.

Calculator keyboard. Statements or calculations may be executed immediately from the keyboard.

Keyboard

Standard typewriter keyboard.

Full 128 ASCII character upper and lower case with auto repeat.

10 key numeric and 5 math function calculator key pad.

5 line/character editor keys.

User definable function keys; 10-shiftable to 20.

Keys for single step program execution, auto numbering, rewinding magnetic tape, making copies, or automatic loading and execution of the first program on tape.

Tape Drive

3M® DC300A cartridge.

300K bytes maximum.

Rewind speed: 90ips

Search/read speed: 30ips

Structure: 256 bytes with header (128 byte headerless format selectable for 4923 tape compatibility).

Standard Built-in Functions

Math and Trigonometric:
* (multiply)
/ (divide)
± (add/subtract)
↑ (power), SQR
LOG, EXP(e^x), LGT(10)
SIN, ASN, COS, ACS
TAN, ATN, PI
ABS, MIN, MAX
SGN, INT, RND (random)
SUM (matrix)
DEF FN (define function)

Relational: =, >, <, <>, =>, =<

Logical: AND, OR, NOT

Assignment: DIM, LET (optional),

Character String: & (concatenate)
CHR (decimal to ASCII)
ASC (ASCII to decimal)
STR (numeric to ASCII string)
VAL (ASCII string to numeric)
SEGMENT, POSITION
LENGTH, REPLACE

Graphic Commands:
MOVE, DRAW
RMOVE, RDRAW (relative)
VIEWPORT, WINDOW
SCALE, AXIS, ALPHASCALE
ROTATE, ALPHAROTATE
GIN (input x, y), POINTER
DASH (Dot-dashed patterns)

Program Preparation and Debug:
LIST
REM (remarks)
REN (renumber)

Matrix Commands: TRN (transpose), IDN (identify), MPY (matrix product), DET (determinant), INV (inverse)

Memory Management:
DELETE (variable or program)
MEMORY (bytes available)
SPACE (bytes required to store current program on tape)

Program Flow: FOR . . . TO, NEXT, GOSUB, RETURN, IF . . . THEN, RUN, STOP, END, GO TO, GO TO . . . OF, GOSUB . . . OF

Environmental:
INIT (initialize)
SET (degrees, radians, grads)
FUZZ
SET CASE (upper or upper/lower)
SET KEY, NO KEY
SET FONT (U.S., European, other)
SET TRACE, NORMAL
CHAR (4 character sizes)

Interrupt Handling: POLL, WAIT, ON . . . THEN, OFF

Mag. Tape: FIND, MARK, TLIST, CLOSE, TYPE, KILL, MTPACK

System Control: CALL, COPY, HOME, PAGE

Data Input/Output: READ, WRITE, RBYTE, WBYTE, DATA, RESTORE, INPUT, PRINT, PRINT USING, IMAGE

ASCII Program Input/Output: OLD, APPEND, SAVE, SECRET

Binary Program Input/Output: BOLD, BAPPEN, BSAVE, SECRET

CRT

Type: Direct View Storage CRT.

Display area: 38.5cm (15") wide, 28.2cm (11") high, 48.2cm (19") diagonal.

Alphanumerics: Four program selectable formats.

72 characters per line with 35 lines per display.

79 characters per line with 38 lines per display.

119 characters per line with 58 lines per display.

132 characters per line with 64 lines per display.

Character set: Full ASCII, upper/lower case, high quality, stroke generated characters.

Special fonts: Selectable under program control — Swedish, German, British, Spanish, Danish/Norwegian, Graphic and Business.

Graphics:

Vector drawing time—15kcm/sec.

Addressable resolution: 4096 (x) by 4096 (y) — 12 bits.

Viewable resolution—4096 (x) by 3125 (y).

Dot-dashed vectors, programmable in 36 unique patterns.

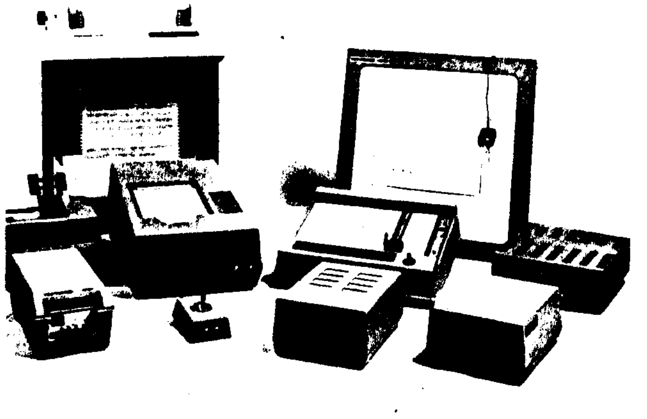
Cross-hair cursor with built-in thumbwheels for interactivity.

Visibility: Flicker-free, easy-on-the-eyes display.

Copier: Compatible with Tektronix hard copy units.

General Purpose Interface Bus (GPIB)

The Tektronix GPIB interface conforms to IEEE Standard 488-1975. Transfer is byte serial, bit parallel. External devices can be serviced via 4054 BASIC language commands for interrupt, enable/disable, polling and data transfer.



Optional Interfaces

The Data Communications Interface (Option 1) allows full or half duplex asynchronous data sharing with your host at up to 9600 baud. This option enables the 4054 to function as a terminal with direct host-to-4054 tape transfer of data. Ease of use is facilitated by a special function key overlay and added language commands that make communication parameters and communications programmable.

The Printer Interface (Option 10) allows connecting the 4054 to any compatible EIA RS-232 printer, or to any device conforming to the RS-244A Standard for EIA Numerical Machine Control. Data rates are switch-selectable to 50,75,134.5, 110,150,200,300,600,1200,1800, 2400,4800,9600 or 16X external clocking.

Peripherals

4631 Hard Copy Unit
Delivers clean, dry 21.6cm (8.5") x 28cm (11") copies of the CRT screen, both graphics and alphanumerics, in 18 seconds or less.

4641 Line Printer
Prints alphanumeric data at up to 180 cps on a variety of single or multipart forms (includes Opt. 10).

4642 Line Printer
Prints at up to 60 cps on inexpensive roll paper. Regular and elongated characters are available in 80 column and 132 column formats (includes Opt. 10).

4924 Digital Tape Unit
Provides 300K bytes of on-line GPIB compatible auxiliary storage. Has intelligence for off-line data collecting and recording.

4907 File Management System
An intelligent GPIB compatible mass storage system that is directory and file oriented. Available with up to three double density disc drives of 630K bytes each.

4952 Joystick
Provides graphic input and cursor positioning via a standard built-in interface and connector.

4956 Graphic Tablet
GPIB compatible graphic input and digitizing tablet with .1mm (.005") resolution. Allows digitizing of maps, schematics, photographic or other two dimensional images. Available in standard 51cm (20") 51cm x (20") or with Opt. 30, 91cm (36") x 122cm (48") surfaces.

4662 Interactive Digital Plotter ("B" Size)
GPIB and RS232-C compatible production of camera ready multi-color plots on paper or acetate up to 25.6cm (10") x 38.2cm (15"). Microprocessor driven to provide full upper and lower case ASCII alphanumeric stroke-generated characters and accurate (repeatable to 2.5 mils) vector graphics.

4663 Interactive Digital Plotter ("C" Size)
GPIB and RS232-C compatible with many of the quality features of the 4662 plus circular interpolation, paper advance, multiple parameter entry and storage, multiple pens, and many others. The 4663 plots camera ready output on paper or acetate up to 43cm (17") x 56cm (22") with repeatability at ±.05 mm (.0025") at a plotting speed of 41-56 cmps (16-22ips).

Plug-in Functions (ROM Packs)

ROM packs extend the already powerful BASIC even further, with functions running faster than equivalent BASIC routines. The ROMs are easily installed in the slots located on the back of your system. The following functions are presently available.

4052R06: Editor ROM Pack
Allows general ASCII file editing of data, text or programs (including FORTRAN, COBOL, and BASIC) off-line. Powerful commands include MOVE, INSERT, SEARCH, and SORT, plus 20 others.

4052R07: Signal Processing ROM Pack #1
Adds seven new functions which can be applied to one dimensional data arrays: integration, differetiation (2 and 3 point), fast graphing, locating minimum and maximum, and crossing over a threshold. Functions operate 2-10 times faster than equivalent BASIC routines.

Backpacks
The standard backpack contains two slots for insertion of ROM packs. Ordered with Option 2 there are four locations for ROMs. Option 3 is available and contains four ROM slots and the Data Communications Interface.

4054
Physical Characteristics

Height: 51.3 cm (20 inches)
Width: 67.4 cm (26.3 inches)
Depth: 88 cm (34.3 inches)
Weight: 65.8 kg (145 pounds)
Power Requirements:

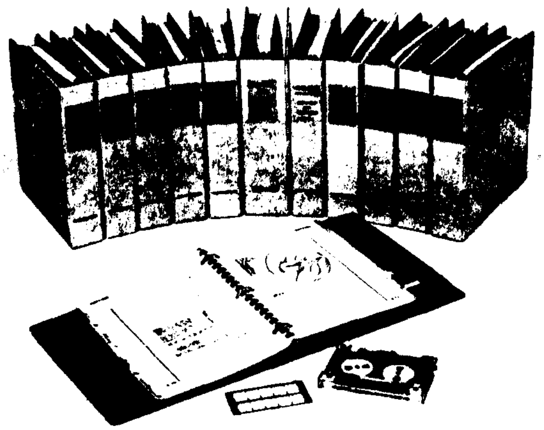
Line Voltage Range ±10%		
Low	High	
100	120	operates between 90 V to 132 V RMS.
220	240	operates between 198 V to 264 V RMS.

Line frequency: 48-66 HZ

Power Consumption: 360 W maximum

Operating Temperature:
+10 degrees C to +40 degrees C

Plot 50 Software



Written in easy BASIC, these volumes are solution oriented.

- —**General Purpose Mathematics** (2 volumes) for root finding, coordinate conversion, Gamma, Bessel functions, plus many more including general function plotting, linear programming and Fast Fourier Transformation (FFT).
- —**Statistics** (4 volumes) including the most comprehensive non-linear regression package available.
- —**Electrical Engineering** including general steady state A.C. circuit analysis plus microwave design aids with Smith chart graphing and mapping.
- —**Graph Plot** for developing graphs and diagrams for camera ready copy or for presentations of data.
- —**Business Planning & Analysis** includes break-even analysis, probability indices, payback plots, and many other business graphics and problem solving routines.
- —**General Utility Programs** for tape duplication, BASIC program editing, sorting of strings or data, and tape file labeling. Also included is a program that generates easy-to-read formatted listings of any BASIC program. Utility programs are designed to aid the user in everyday tasks.
- —**Modeling and Reporting Software** is a general purpose modeling and reporting system that allows the user to automate analysis and reporting processes. Optimized for user convenience, the software requires no previous computer experience to produce report quality graphics and tabular reports. The model and report structure can be saved on tape or disc for future use.

Applications Software Library

Written in easy BASIC by 4050 Series users, these library programs may save you from reinventing an already existent program. Some of the applications include:

- —**Electrical Engineering** logic circuit behavior analysis.
- —**Mechanical Engineering.**
- —**Statistics**—including a response graphing package employing Kaplan-Meier survival techniques.
- —**Education** grade recording.
- —**Graphics**— including advanced media graphics, time series graphing, digitized drawing, flow charts, and spider web charts.
- —**Miscellaneous**—including tape duplication, flow diagrams, variable size screen characters and character generation and manipulation.

4050 Series owners and users are encouraged to join and contribute to the 4050 Series Applications Library. A free newsletter, TEKniques, informs members of other users' applications, programming tips, new programs added to the central library, and new 4050 Series related products.

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Cable SONYTEK Tokyo

Tektronix Australia Pty. Limited
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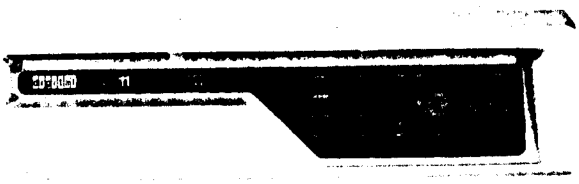
Cable TEKANADA

Tektronix
COMMITTED TO EXCELLENCE

APPENDIX G

DECLAB-11/34 Hardware

THE PROCESSOR



PDP-11/34

The PDP-11/34 is a midrange member of the PDP-11 family of processors with an excellent performance/price ratio. As a microprogrammed processor, the PDP-11/34 CPU is so compact that the entire CPU logic is contained on two circuit boards. This provides greater flexibility during later system expansion by making additional chassis space available.

The Memory Management is an advanced memory extension, relocation and protection feature. The Memory Management provides extended memory space from 28K to 124K words; plus, efficient segmentation, and effective protection of memory segments in multi-user environments.

Self-test Diagnostic Routines are automatically executed every time the processor is powered up, the console emulator routine is initiated, or the bootstrap routine is initiated.

Operator front panel with built-in CPU console emulator allows control from any ASCII terminal without the need for the conventional front panel with display lights and switches.

Automatic bootstrap loader allows system restart from a variety of peripheral devices without manual switch toggling or key-pad operations.

The central processor contains eight general registers which can be used for a variety of purposes. The registers can be used as accumulators, index register, auto increment or auto decrement registers, as well as stack pointers for temporary storage of data. The instruction complement uses the flexibility of the general-purpose registers to provide over 400 powerful hard-wired instructions – the most comprehensive and powerful instruction repertoire of any computer in the 16-bit class.

The Extended Instruction Set (EIS) provides the capability of performing hardware fixed-point arithmetic and allows direct implementation of multiply, divide, and multiple shifting. A double-precision, 32-bit word can be handled. The Extended Instruction Set executes compatibly with the EIS available on the 11/40.

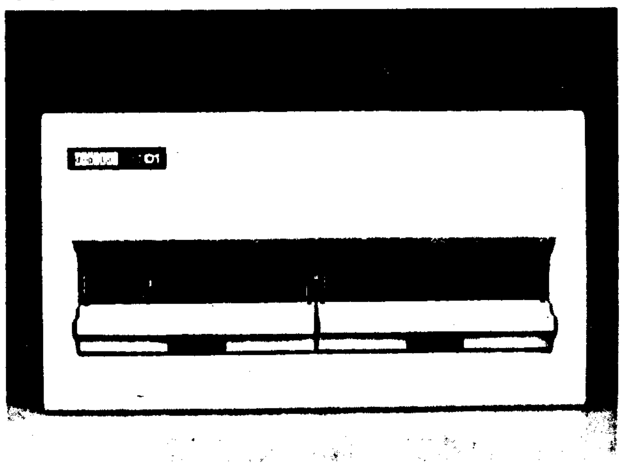
The interrupt system for the PDP-11 is another feature, generally found only in large computer technology, included at no extra cost. With fully vectored interrupts, the system eliminates the high overhead software that determines which device service routine to use and the code necessary to save system status.

Battery backup is optionally available for MOS memory systems. It can preserve the contents of a 32K word 11/34 for about two hours.

Expansion of PDP-11/34 based systems is easily accomplished by the UNIBUS™ and the over 60 standard available UNIBUS peripherals. Memory as well as peripheral devices are interconnected by the UNIBUS.

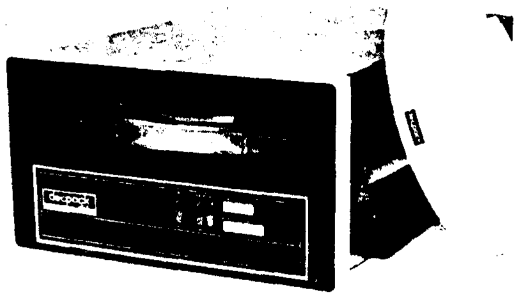
The FP11-A floating-point unit is an optional arithmetic processor which fits integrally into the PDP-11/34 central processor. It performs all floating-point arithmetic operations and converts data between integer and floating-point formats. This option provides a time and money saving alternative to software floating-point routines. Its use results in orders of magnitude improvement for arithmetic operations. This option provides flexible addressing in addition to single and double precision (32- or 64-bit) floating-point modes; and it is fully program compatible with all double-precision PDP-11 floating-point processor options.

MASS STORAGE SUBSYSTEMS



Floppy Disk

The floppy disk subsystem is a highly reliable, low-cost, mass storage subsystem, capable of storing up to 256K 8-bit bytes per drive in an industry-compatible format. The subsystem provides a compact data interchange and software distribution medium for critical I/O applications. The system includes two drives for a total storage capacity of 512K bytes, on-line.

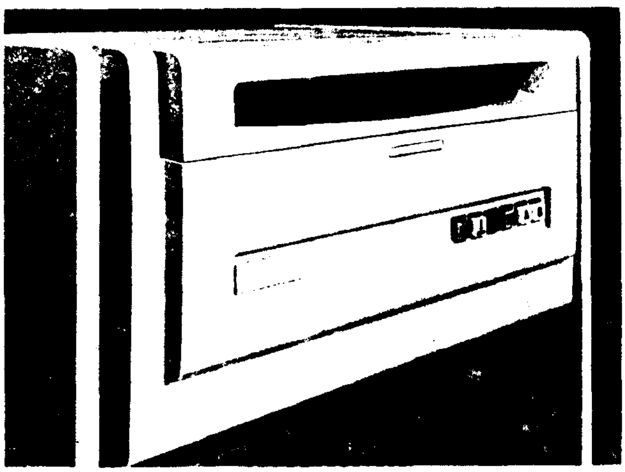


DECpack Disk

This disk subsystem for the DECLAB-11/34 family includes a disk controller and two drives. It is a complete mass storage system ideal for random access data storage. One drive utilizes a removable disk cartridge with 2.4 million bytes (8-bit bytes) capacity. The other drive utilizes a fixed disk drive with an additional 4.8 million bytes for a total of 7.2 million bytes per system.

The cartridge drive allows system users to keep all their files on a personal cartridge to ensure the integrity of their data.

The DECpack features a transfer time of 11.1 micro-seconds/word. Average total access time on a disk drive is 70 milliseconds. All data transfers are DMA (direct memory access).



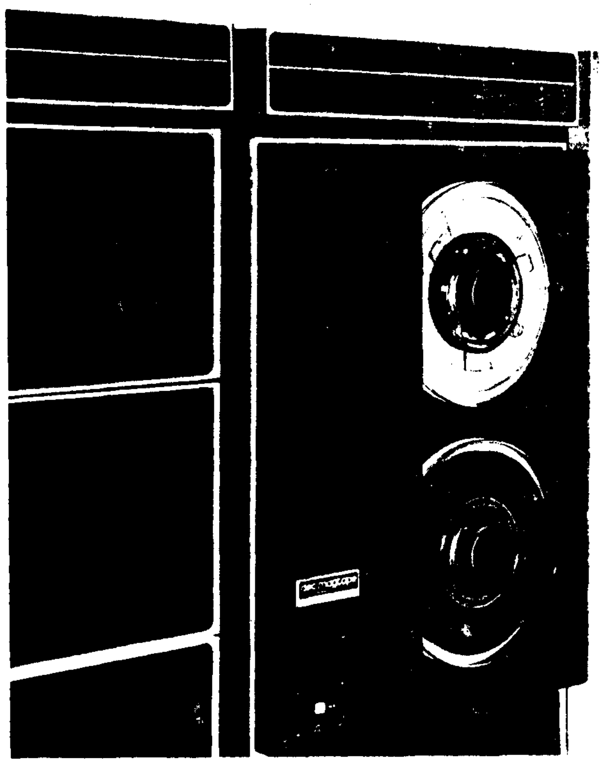
RK611/RK06 Disk

The RK611/RK06 disk system offers a removable, dual-platter disk pack with a capacity of 13.8M bytes. This high-performance mass storage device has an average transfer time of less than 4.3 μsec per word, and an average access time of less than 38 ms.

The controller (RK611) is capable of handling eight drives. In addition, an optional feature allows two controllers to access the same drive(s) for dual access capability.

Numerous diagnostic and reliability features have been built in, including Error Correction Code (ECC), detailed system status registers and a special diagnostic mode of operation.

The RK611/RK06 is ideally suited for applications requiring medium-sized, expandable data storage while maintaining high performance.



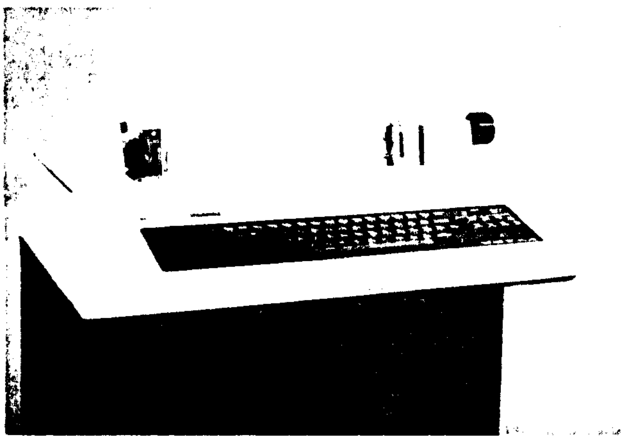
Magnetic Tape

Magnetic tape is a commonly used media for system backup and is also used for transporting data between separate systems. DIGITAL's tape systems allow low cost as well as high performance capabilities.

As an example, the TE10W (pictured above), is a mid-range magnetic tape system. It features 7- or 9-track recording, using 200-, 556-, or 800-bpi NRZI format. The 10-1/2 inch reel capacity provides 17 million characters of storage on a 2400-foot tape. The drive operates at 45 inches per second, yielding a transfer rate of up to 36,000 characters per second.

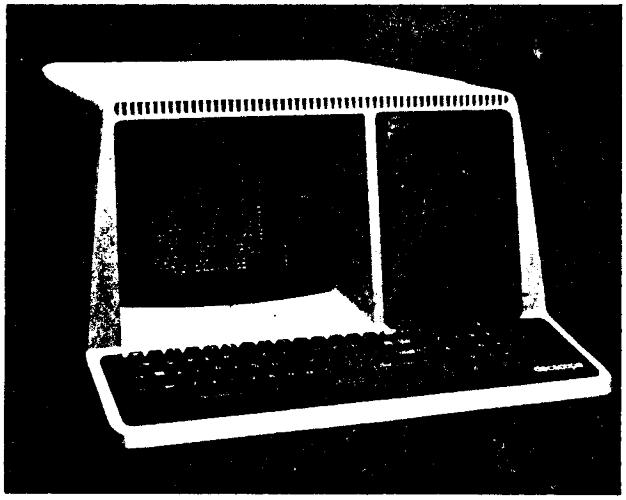
The TS03 is a low-cost, 9-track system using industry-standard 800-bpi NRZI recording format. The 7-inch reels allow 4 million characters to be stored per tape. The high reliability drive operates at 12-1/2 ips.

TERMINALS



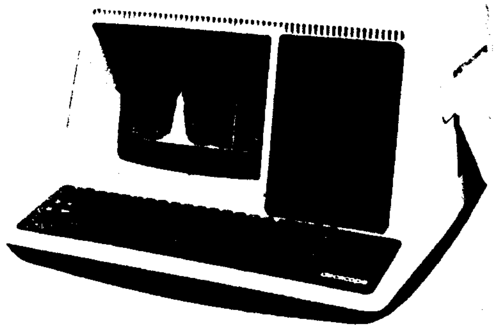
DECwriter II

The DECwriter II is designed to be the industry's lowest-priced, best performing, most reliable 30-cps impact teleprinter. DECwriter II is packed with capability: it's fast--a true 30 characters per second printer; it's quiet and has many people-oriented design considerations you wouldn't expect in a cost-conscious product; it's versatile--you can use 6-part forms and even standard 132-column line printer paper; and it's built for a long, reliable lifetime of heavy use.



DECscope

The large-screen, video display terminal allows instructions and solutions to be clearly visible to the user. It offers both upper and lower case and will display 24 lines of 80 characters. To move about in files containing more than 24 lines, the terminal can scroll the information up and down on its screen. The operator merely requests the host by a command to end the editing session, and the host writes its screen image into a storage device. It is also possible to change individual lines of text rather than the whole screen.

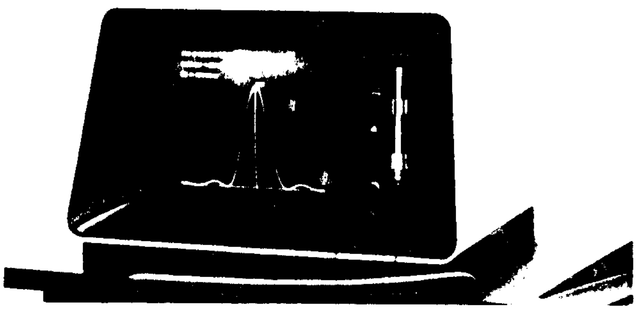


VT55 Graphic Terminal

The VT55 is an on-line interactive CRT terminal that offers waveform graphics capability. Two graphs of 512 (maximum) data points each can be displayed with a screen resolution of 512 points (x) by 236 points (y). Cursors (20-point vertical lines) are available (one per data point) to facilitate data editing and graph generation. In addition, the VT55 allows simultaneous display of any combination of text and graphics. By simply pressing a specified key, the VT55 supplies a hardcopy reproduction of the display screen for both characters and graphs.

The VT55 can hold up to 1,920 characters in 24 lines of an 80 characters-per-line matrix. The 24th line of text is positioned below any graphs to facilitate labeling the x axis.

Waveform graphics capability is an important addition to applications involved with such activities as plotting histograms and waveforms, data acquisition, monitoring, trending, simulation, laboratory charts and forms . . . wherever results can be improved through graphics with extended capability.

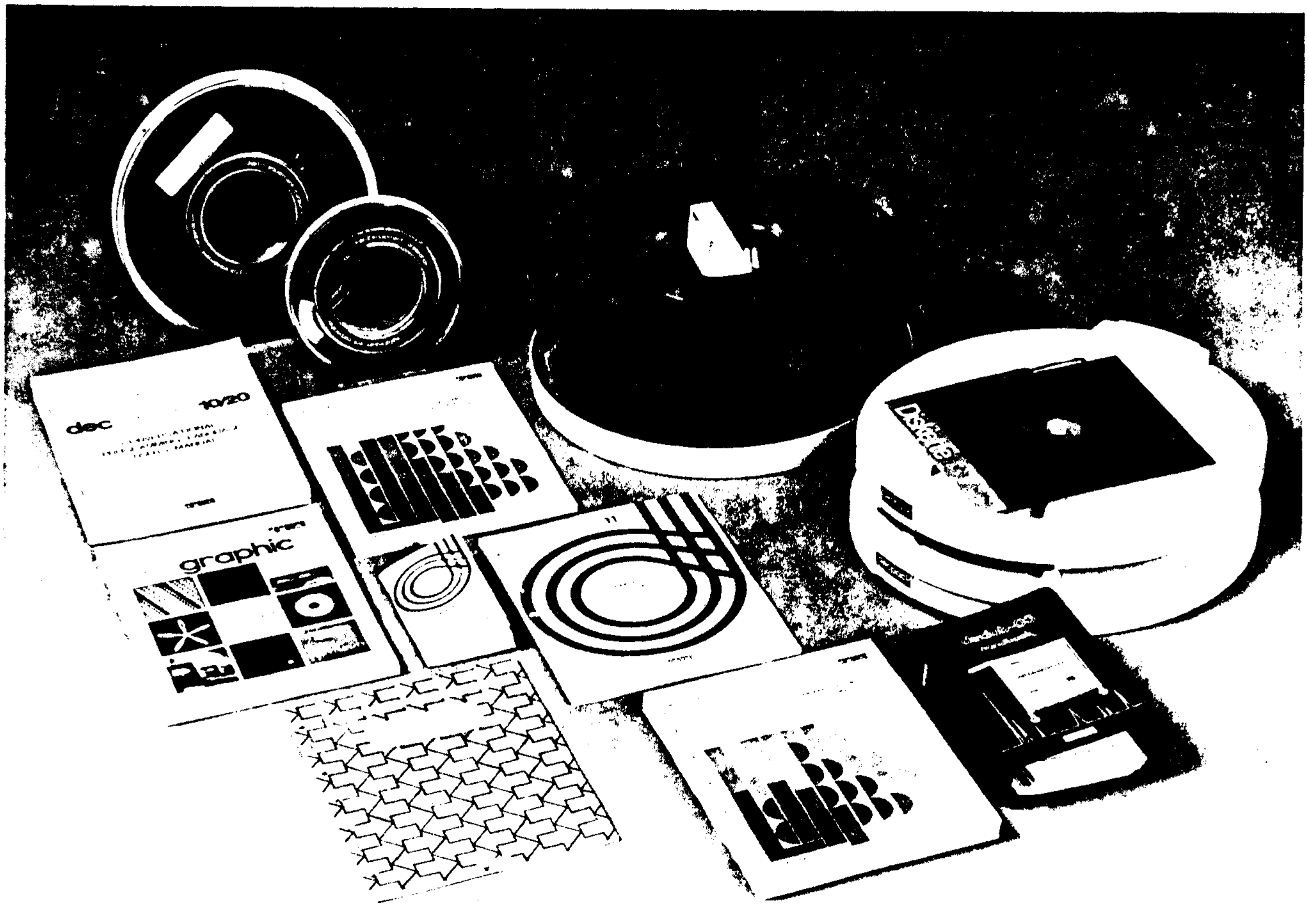


VT11 Graphic System

The VT11 provides interactive graphics capability. The

Software

THE OPERATING SYSTEMS



RT-11

RT-11 is a high-performance, real-time operating system that combines powerful computing hardware and software; the system will operate in either a single-user or a foreground/background mode. The system is ideally suited for the single user involved in real-time program development for a scientific or research environment and provides on-line access to the full power and features of the PDP-11.

System Features

FOREGROUND/BACKGROUND processing facilitates real-time data acquisition in the foreground concurrent with data analysis and reduction or program development in the background.

EASE OF USE makes RT-11 an instant tool for the scientific researcher; the software arrives ready to run. Keyboard commands are consistent and fast; system messages are clear and concise.

ASYNCHRONOUS, QUEUED I/O facilitates any number of independent operations and simplifies double buffering for enhanced I/O throughput.

CONFIGURATION INDEPENDENCE allows RT-11 users to transport their system to any size memory from 8K-124K words without a system regeneration.

RT-11 BATCH is a complete job control subsystem which provides batch-mode processing of user jobs. In the foreground/background environment, BATCH processes job streams in the background partition, allowing real-time or other user jobs to run in the foreground.

RSX-11M

RSX-11M is designed for applications requiring multiple users controlling concurrent real-time tasks. Its event-driven, priority-structured scheduler exploits the powerful interrupt-handling capabilities of the PDP-11. RSX-11M, through system generation and on-line interaction, allows the system to be tailored to specific applications and modified dynamically to meet changing environments.

System Features

MULTITASKING. Allows concurrent processing of two or more tasks residing in memory and facilitates communication between those tasks.

EVENT-DRIVEN PRIORITY SCHEDULING. Task scheduling is event driven, ensuring that any scheduled task can respond quickly to real-time data input or I/O completion. The scheduler recognizes 250 priority levels, which allows fine-tuning of system response.

DYNAMIC MEMORY ALLOCATION. Tasks are automatically loaded and swapped out of memory as they become active or are suspended. Memory compaction minimizes fragmentation of available memory space.

LANGUAGE SUPPORT. RSX-11M supports MACRO, FORTRAN IV, FORTRAN IV-PLUS, BASIC, and COBOL.

THE LANGUAGES

RT-11 FORTRAN IV

The motivating factor for the emergence of language processors has been to provide a workable man/machine interface. FORTRAN IV, a problem-oriented language provides such an interface because it is designed to help scientists and engineers express computation by means of simple and familiar notation. Its commands are descriptive of the functions they perform, and the notation system is similar to that of conventional mathematics.

RT-11 FORTRAN IV is ANSI-compatible and supports one-word integers, double precision, real, complex, logical, and logical*1 data types.

The FORTRAN IV software also includes a library of real-time support subroutines for laboratory I/O hardware. Subroutines exist for the reading of analog channels, control of digital input/output and the output of analog signals. Additional subroutines are available, for example, to measure elapsed time between events, display graphics on a CRT, and obtain Inter-Stimulus-Interval data. The VT-55 video graphics terminal is also supported by FORTRAN IV.

The FORTRAN library includes a full set of graphic subroutines which exploit all features of the VT11 and VS60 display processors. The graphics support includes graphic subroutines which facilitate the creation, repetition, and tracking of multifaceted figures. The light pen support includes isolation on light pen sensitive points, vectors, and sub-pictures.

FORTRAN IV-PLUS

FORTRAN IV-PLUS is an optimizing compiler yielding code which typically runs two to three times faster than a FORTRAN IV program on identical hardware. Also included are enhancements to the language in additional I/O and data format statements.

RT-11 BASIC

BASIC™ is a conversational, high-level programming language which uses straightforward English-type statements and familiar mathematical notation to perform an operation. The BASIC language embodies powerful yet easily mastered commands which turn novices into overnight "expert" programmers. With experience, the scientific professional can incorporate advanced techniques available in the language to perform more intricate manipulations or express a problem more efficiently and concisely. The power of the language stems from the integration of an exceptionally fast incremental compiler with a number of operating systems and a wide range of peripheral devices.

For the DECLAB-11/34 systems there are an extensive set of BASIC calls that support a wide variety of laboratory and graphics hardware.

APL/RT-11

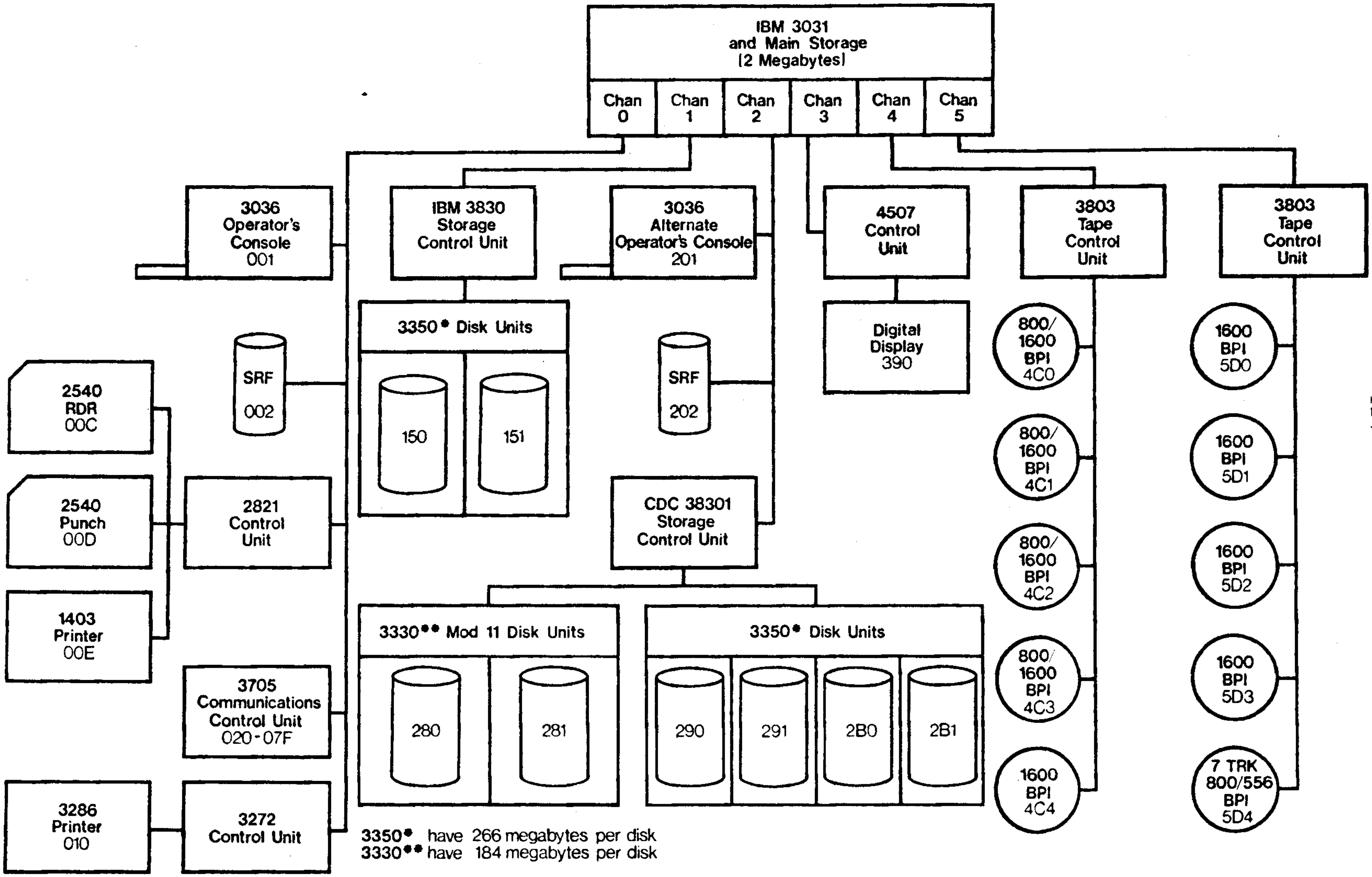
APL is a mathematically-oriented language that is especially suited to handling numeric and character array structured data, but is flexible enough to solve problems in text-handling and commercial data processing. APL uses a concise, consistent and powerful character set, yielding compact source code for a given operation. Because APL is an interpretive language, the user can interact easily with the program, during and after program development.

RT-11 FOCAL

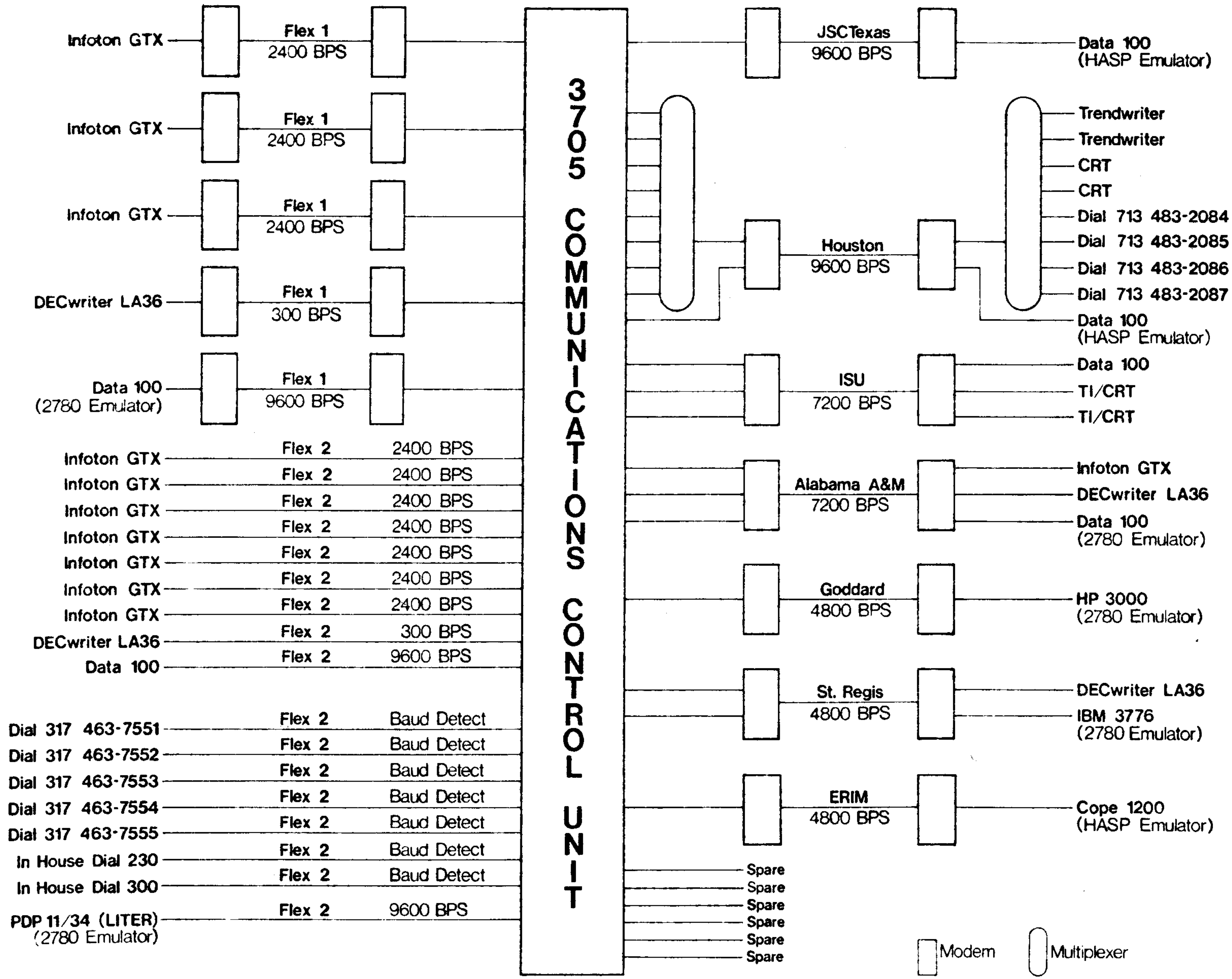
FOCAL-11 (FOrmula CALculator) is a powerful, interactive, high-level programming language designed for scientists who require an easy-to-learn-and-use, real-time language. FOCAL provides both data acquisition and experiment control, as well as data analysis capabilities. FOCAL allows calculations and operations to be performed immediately in response to a user command (calculator mode); or, the user can create programs from these commands. Because there are no separate edit, compile, link, and load phases, FOCAL users can rapidly develop, debug, and modify problem-solving programs.

APPENDIX H

3031 Hardware Configuration



3350* have 266 megabytes per disk
3330** have 184 megabytes per disk


3705 COMMUNICATIONS CONTROL UNIT
Infoton GTX
Flex 1
2400 BPS
Infoton GTX
Flex 1
2400 BPS
Infoton GTX
Flex 1
2400 BPS
DECwriter LA36
Flex 1
300 BPS
Data 100
(2780 Emulator)
Flex 1
9600 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
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2400 BPS
Infoton GTX
Flex 2
2400 BPS
Infoton GTX
Flex 2
2400 BPS
DECwriter LA36
Flex 2
300 BPS
Data 100
Flex 2
9600 BPS
Dial 317 463-7551
Flex 2
Baud Detect
Dial 317 463-7552
Flex 2
Baud Detect
Dial 317 463-7553
Flex 2
Baud Detect
Dial 317 463-7554
Flex 2
Baud Detect
Dial 317 463-7555
Flex 2
Baud Detect
In House Dial 230
Flex 2
Baud Detect
In House Dial 300
Flex 2
Baud Detect
PDP 11/34 (LITER)
(2780 Emulator)
Flex 2
9600 BPS
JSCTexas
9600 BPS
Data 100
(HASP Emulator)
Houston
9600 BPS
Trendwriter
Trendwriter
CRT
CRT
Dial 713 483-2084
Dial 713 483-2085
Dial 713 483-2086
Dial 713 483-2087
Data 100
(HASP Emulator)
ISU
7200 BPS
Data 100
TI/CRT
TI/CRT
Alabama A&M
7200 BPS
Infoton GTX
DECwriter LA36
Data 100
(2780 Emulator)
Goddard
4800 BPS
HP 3000
(2780 Emulator)
St. Regis
4800 BPS
DECwriter LA36
IBM 3776
(2780 Emulator)
ERIM
4800 BPS
Cope 1200
(HASP Emulator)
Spare
Spare
Spare
Spare
Spare
Spare
Modem
Multiplexer