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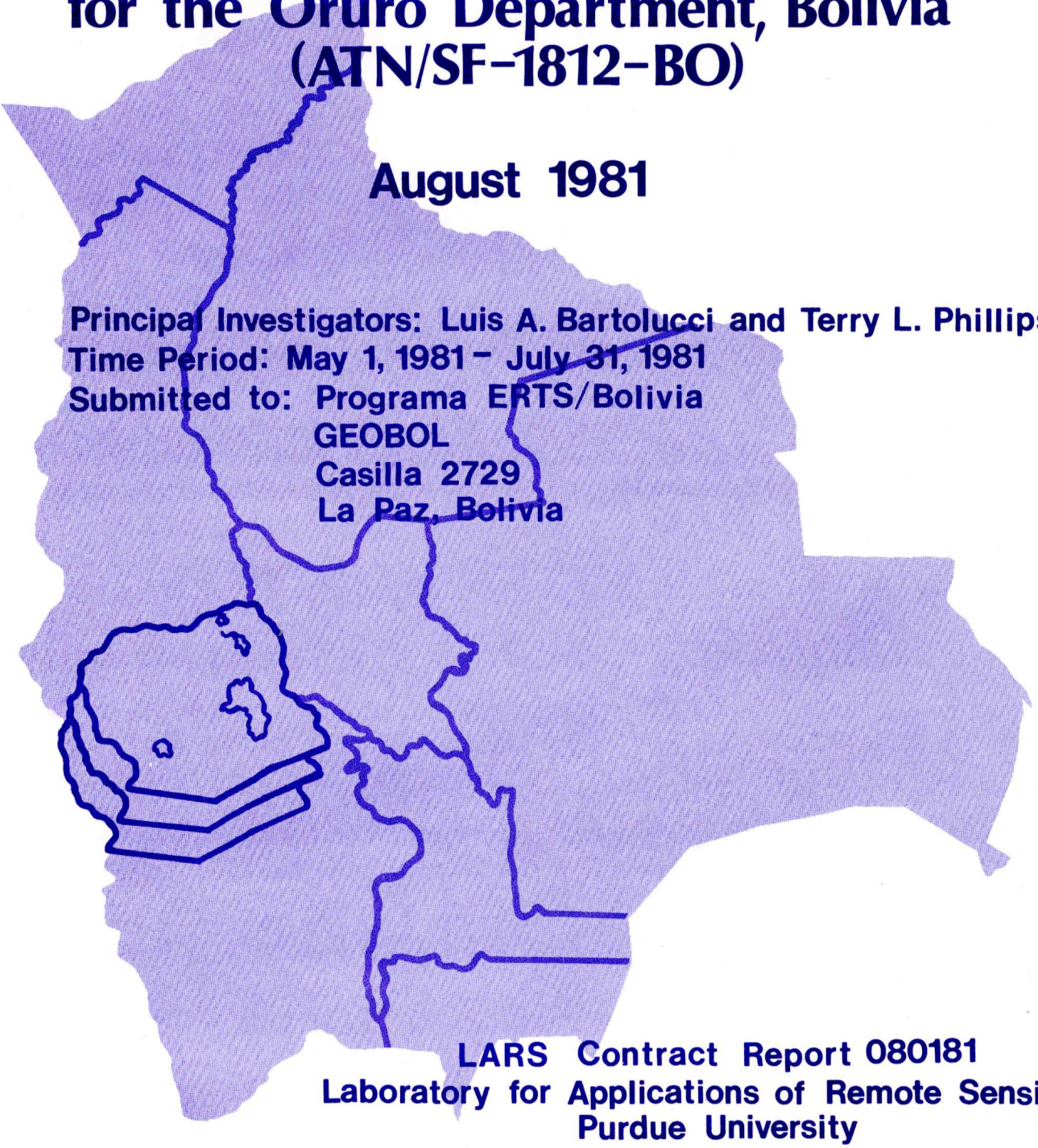
Part I
Quarterly Progress Report

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

August 1981



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

Time Period: May 1, 1981 - July 31, 1981

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

LARS Contract Report 080181

Laboratory for Applications of Remote Sensing
Purdue University
West Lafayette, Indiana 47906
USA

QUARTERLY PROGRESS REPORT

Period: May 1, 1981 - July 31, 1981

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Digital Geographic Information System for the Oruro Department, Bolivia

INTRODUCTION

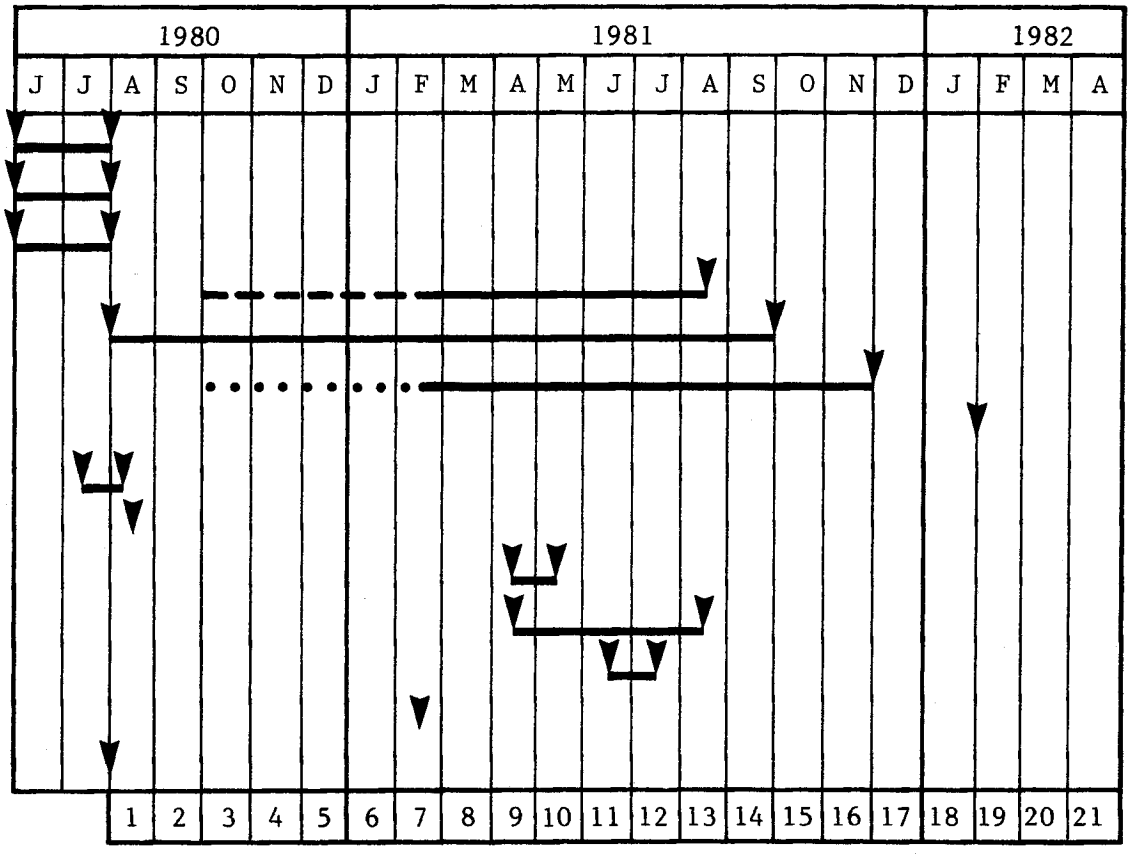
During this reporting period, i.e. May 1 - July 31, 1981, work was continued on tasks 4, 5, 6, 10, 11, and 12 of the revised Project Implementation Plan shown in Figure 1. The major changes in the Implementation Plan took place in tasks 10, 11, and 12 which become apparent when comparing Figure 1 of this report with Figure 1 of the previous quarterly progress report.

The most important item contained in the present report is the documentation of the Input Subsystem. This documentation consists of two parts. Part I is the User's manual and Part II contains the description of the Input Subsystem computer programs and their source listings. The software documentation or system manual (Part II) was compiled by Ing. Percy Grundy from the Bolivian ERTS/GEOBOL Program.

CREATION OF THE LANDSAT DIGITAL MOSAIC

The latest communication with the Jet Propulsion Laboratory (JPL) indicates that the activity of digitally mosaicking the seven Landsat frames covering the Oruro Department is in progress. JPL expects to send to LARS, before the end of August, a preliminary digital mosaic of only one Landsat band for inspection and assessment of its visual quality and cartographic accuracy.

TIME TABLE (in months)



TASKS

1. Implementation Plan
2. System Design Draft
3. Specification of Mosaic
4. Creation of Mosaic
5. Specification of Data Base Elements
6. Input of Data Base Elements
7. Delivery of Data Base Results
8. Trip to Bolivia
9. Arrival of Bolivian Graduate Student
10. Work of 1 Bolivian Cartographer at LARS
11. Work of 2 Bolivian Programmers at LARS
12. Review of Project by ERTS Director
13. JPL Trip
14. GEOBOL/Purdue Contract Signed
15. Months After Contract Signed

— — — — Landsat MSS data evaluation and bad scan line replacement

• • • • • • • Development of Input Subsystem

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

SPECIFICATION OF THE DATA BASE ELEMENTS

The work conducted on this task primarily consisted of a conceptualization of the process of merging socio-economic variables into the Bolivian Geographic Information System. This work was carried out by Professor Roy Chung and is documented in his paper entitled: "Some Observations on Including Socio-Economic Variables in the Bolivian Geographic Information System," which is included in Appendix A of this report.

INPUT OF DATA BASE ELEMENTS

To date, three "elements" have been input into the Oruro Department Geographic Information System, i.e. the political boundaries (according to the Instituto Nacional de Estadisticas' delineation), the land use/land cover element, and the soils element. It is expected that during the next reporting period two other elements will be digitized and included in the information system, i.e., the hydrology and the climatology elements.

BOLIVIAN VISITING SCIENTISTS AT PURDUE/LARS

The active participation of Bolivian scientists in the conceptualization, design, development, and implementation of the Oruro Department Geographic Information System, has proven to be an indispensable requirement for the successful completion of this project.

As reported in the previous quarterly progress report, the Bolivian cartographer, who worked at Purdue/LARS for a period of one month provided the PURDUE/LARS scientists with valuable recommendations regarding the Bolivian requirements on the type and format of map margin information.

Similarly, the two Bolivian computer programmers who worked at LARS for three and four months respectively, were responsible for the software documentation of the Input System (see Part II of this report). It is believed that their contribution was not only useful for the generation of the documentation per se, but the experience they gained will be extremely helpful during the implementation of the system in Bolivia.

Also during the present reporting period, the Executive Director of the ERTS/GEOBOL Program, Cap. Ing. Antonio Perez visited Purdue/LARS for a period of 2 weeks (June 20 - July 2, 1981). During this period Cap. Ing. Perez reviewed the accomplishments of the project.

THE BOLIVIAN DIGITAL GEOGRAPHIC INFORMATION SYSTEM

The basic structural design of the Bolivian digital Geographic Information System is shown diagramatically in Figure 2. It consists of five major subsystems:

1. INPUT SUBSYSTEM
2. DATA BASE SUBSYSTEM
3. MANAGEMENT SUBSYSTEM
4. MODELING OR ANALYSIS SUBSYSTEM
5. OUTPUT SUBSYSTEM

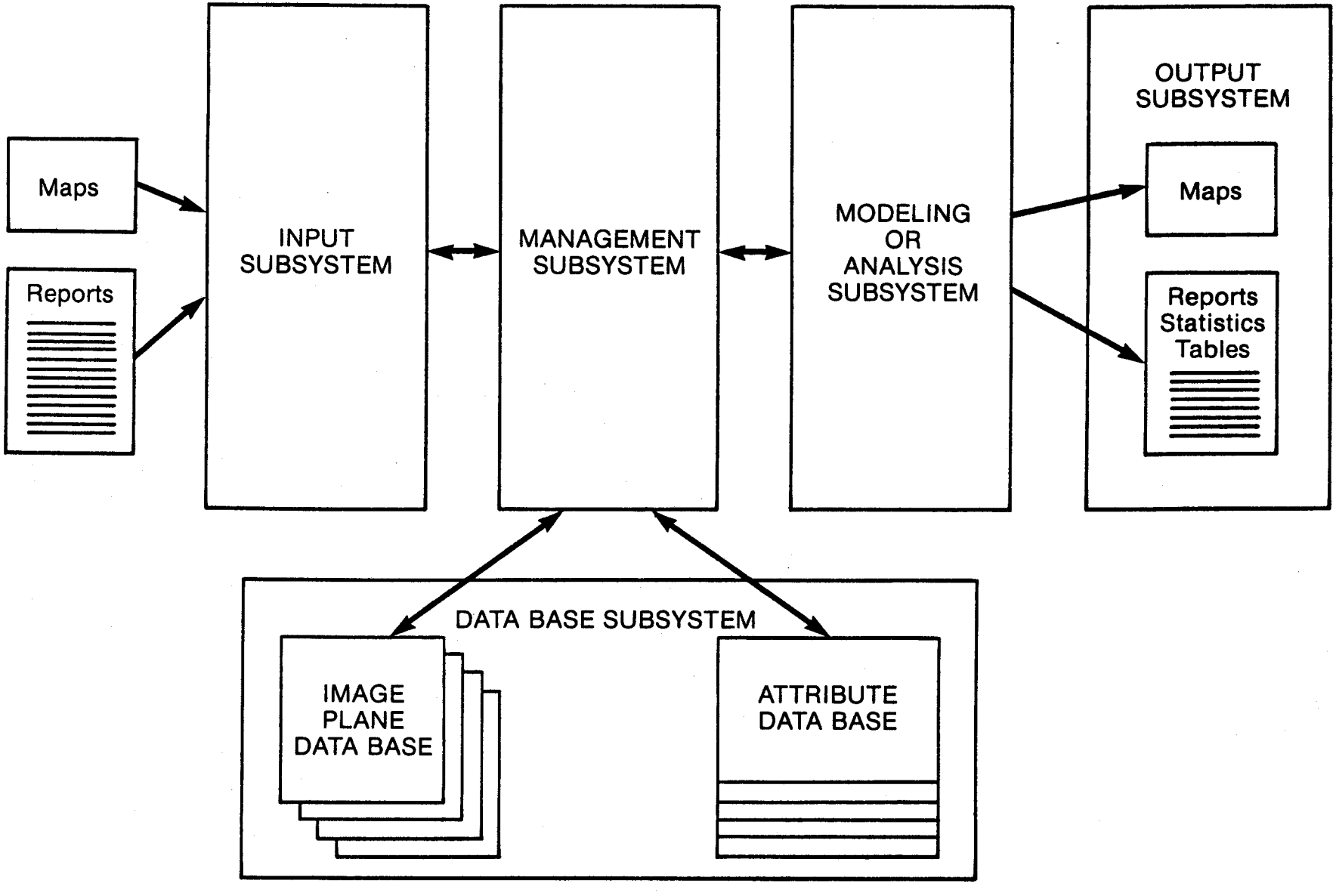


Figure 2. Basic components of a digital Geographic Information System.

Input Subsystem. After the resource data in conventional map format has been properly prepared, that is, once the Map Preparation activity has been completed, the map is converted to a digital form using the Input Subsystem. The Map Preparation activity involves the following steps:

1. Definition of the "data items".*
2. Identification of the data on the map that correspond to the pre-defined data items.
3. Determination of the "data" and definition of the "codes" (coding) that will be used as attributes of the resource classes.
4. Selection and labeling of the "right" and "left" areas of each arc, and marking the "direction of digitization" on the map that is to be digitized. The importance of small features will determine the direction of digitization.
5. Identification and labeling of all "area or region," "linear," and "point" features present on the resource map.

A flow diagram of the Map Input Subsystem developed for this project was given in Figure 26 of the quarterly progress report corresponding to the period November 1, 1980 - January 31, 1981 (LARS Contract Report 020181).

This Map Input Subsystem has been modified by improving and adding new capabilities. Figure 3 shows the flow diagram of the improved Map Input Subsystem. Note that currently, the Map Input Subsystem provides a capability for creating a "centroid" file which is used to facilitate the rasterization or "painting" process. Another new capability added to the Map Input Subsystem permits the user to perform the closure of the digitized

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* A "data item" is defined as the type or category of data that will be input into the GIS.

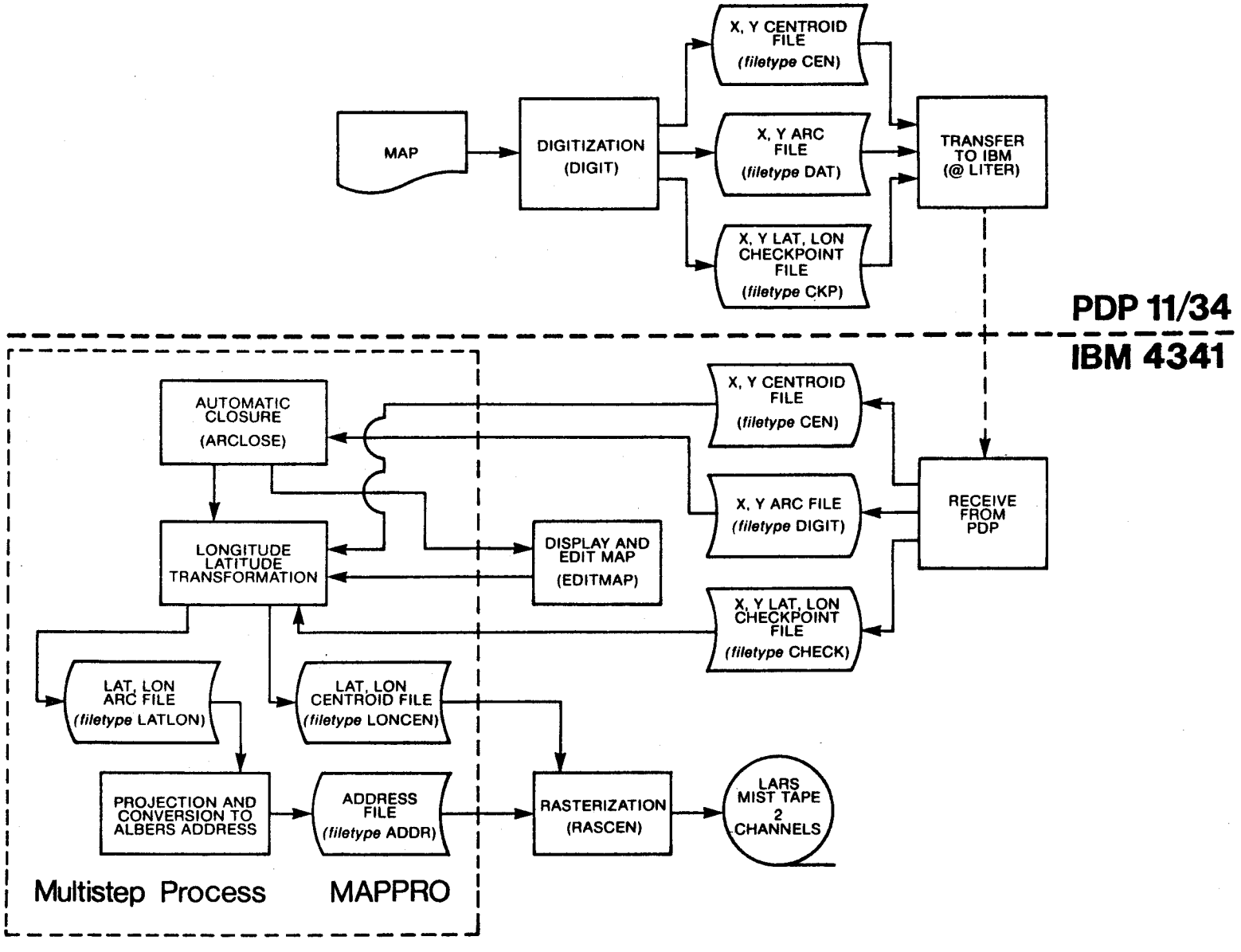

Figure 3. Configuration of the Map Input Subsystem (as of July 31, 1981)

arcs in an automatic fashion; thus greatly decreasing the time required to close the arcs through a manual procedure (EDITMAP).

A detailed description of every process performed by the Map Input Subsystem will be included in a subsequent section of this report entitled INPUT SUBSYSTEM'S USERS DOCUMENTATION. Similarly, the detailed software documentation of this Input Subsystem is provided in Part II of this report (LARS Contract Report 080281).

In addition to the map input capabilities described above, the Bolivian GIS Input Subsystem also includes a capability for inputting descriptive (attribute) information related to the resource map data items. This information is simply input (keyed-in) using a terminal key board. The procedure for entering the attribute information and examples of attribute data files will be given also in the section of this report entitled INPUT SUBSYSTEM'S USERS DOCUMENTATION.

Data Base Subsystem. The definition of "information" from a system's viewpoint can be given by the following simple conceptual equation:

Data + Processing = Information

The relationship between this concept of "information" and the basic components of a digital GIS (shown in Figure 2) is as follows:

Data	+	Processing	=	Information
-Data Base Subsystems		-Management Subsystems -Modeling Subsystem -Output Subsystem		-Output Products

The Input Subsystem is used to create the data base of the system.

In the particular case of the Bolivian digital GIS, the Data Base Subsystem is composed of two different but interrelated data bases, i.e., the Image Plane Data Base, and the Attribute Data Base.

The Image Plane Data Base is composed of a series of layers or channels of digitized maps and/or multispectral scanner (MSS) data. These digitized maps and/or digital MSS data sets are stored in the computer in the form of geo-coded or spatially-referenced image planes. Figure 4 shows the concept of an Image Plane Data Base. Note that the Socio-Economic Space element listed in Table 12 of a previous Contract Report No. 020181, is not present in the Oruro Department Image Plane Data Base shown in Figure 4. The reason for excluding this element from the Image Plane Data Base is that the socio-economic variables available for the Oruro Department, primarily from the 1976 Censo de Poblacion y Vivienda, are based on a minimum spatial mapping unit corresponding to the Canton Political subdivisions within the Oruro Department. Therefore, the socio-economic information for Oruro is stored in the Attribute Data Base corresponding to the Political Boundaries element of the Image Plane Data Base, thus saving considerable storage space.

The Attribute Data Base is composed of records that contain descriptive information related to the Image Plane Data Base. These records are stored in a linked list format. Figure 5 shows the hierarchical structure of the Bolivian Attribute Data Base.

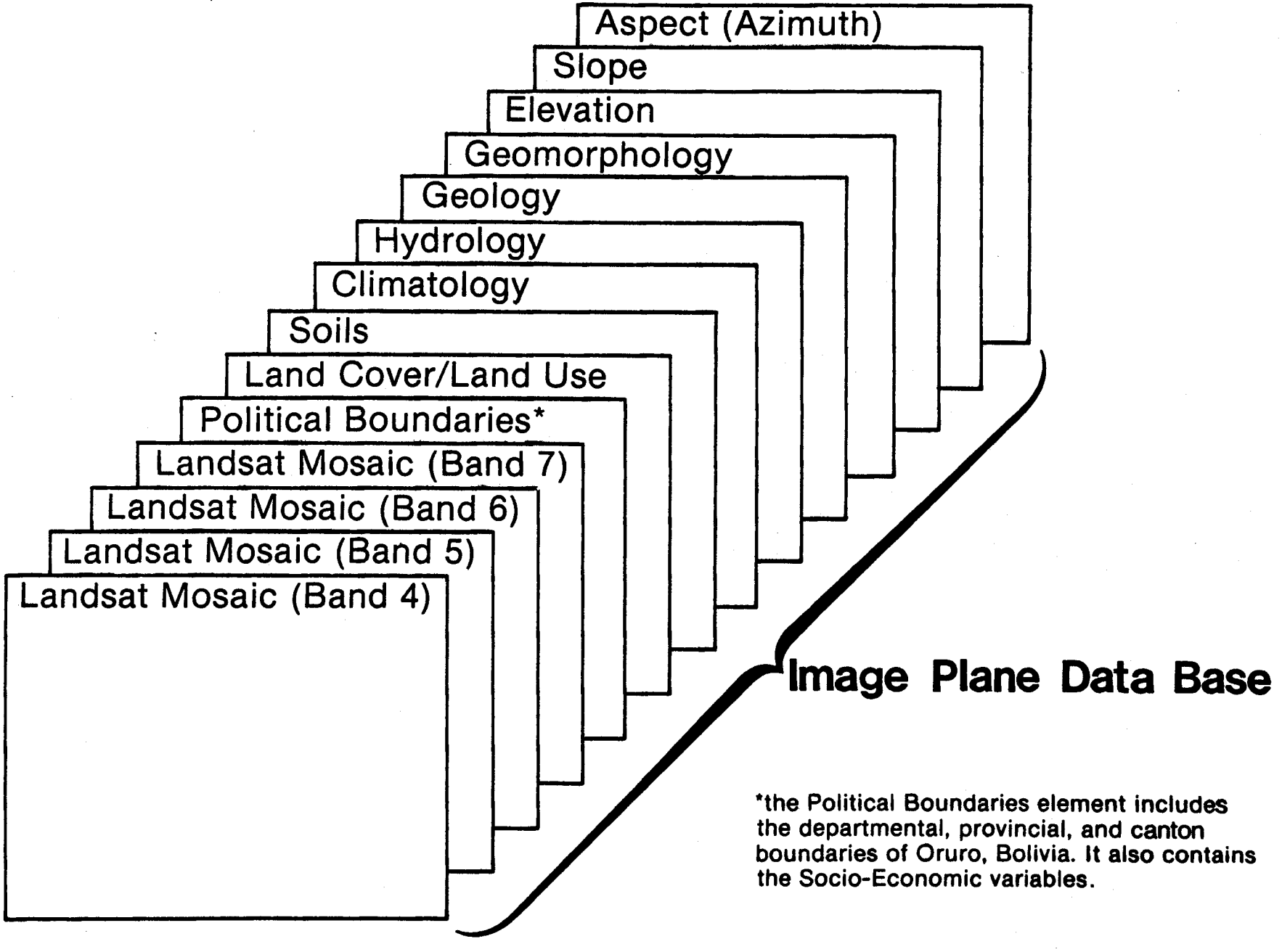

Figure 4. Image Plane Data Base for the Oruro Department GIS.

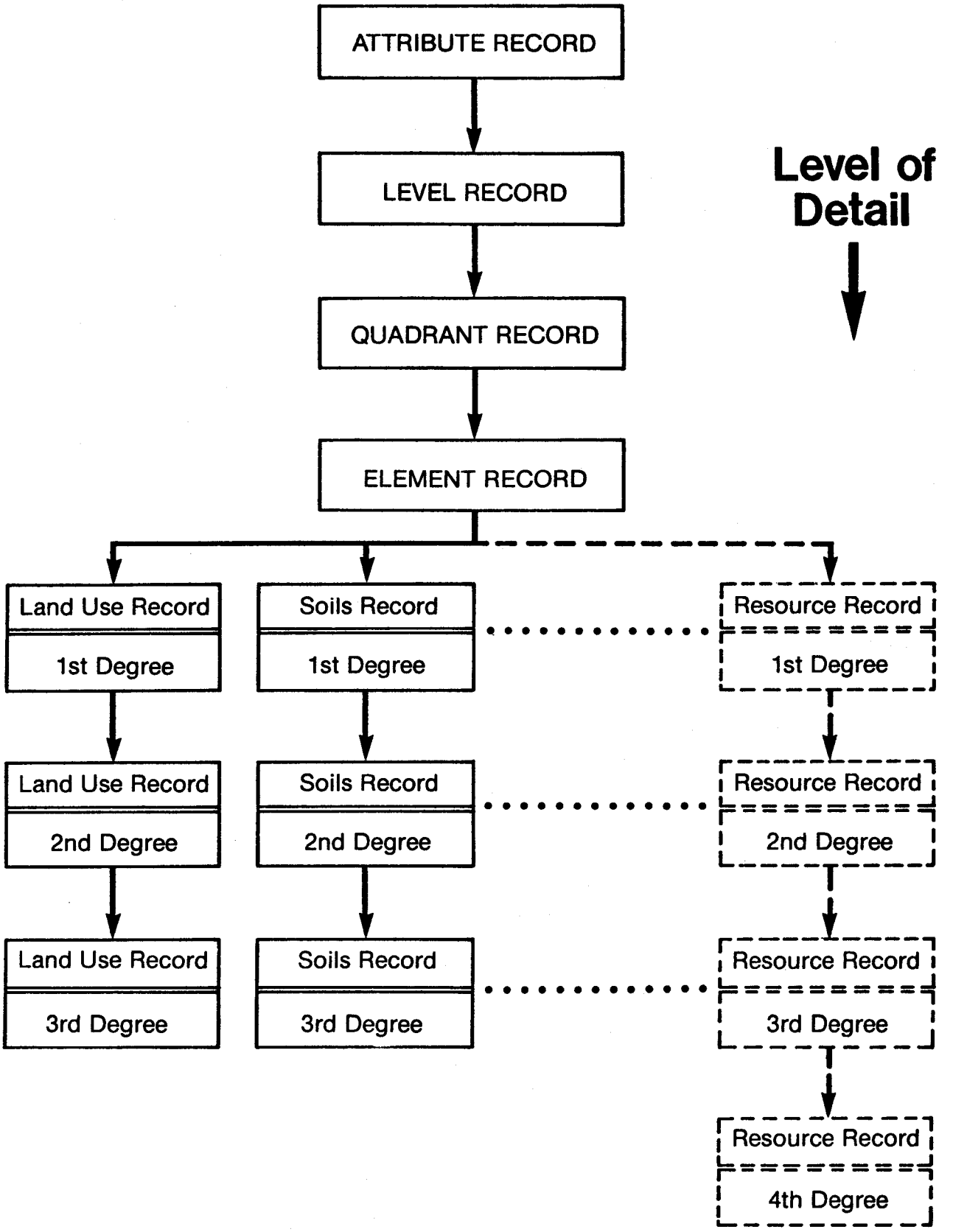

Figure 5. Hierarchical Structure of the Bolivian Attribute Data Base.

Currently, there are seven hierarchical levels implemented in the Bolivian Attribute Data Base:

1. Attribute Data Base Record
2. Level Record
3. Quadrant Record
4. Element Record
5. 1st Sub-Element Record
6. 2nd Sub-Element Record
7. 3rd Sub-Element Record

The types of data that are included in the records corresponding to the seven different hierarchical levels of the Attribute Data Base are given in Table 1.

Table 1. Examples of the Attribute Data Base Contents.

Type of Record	Type of Data
1. ATTRIBUTE DATA BASE	1. Current Date 2. System Title 3. Date of Latest System Update 4. Program Originator 5. Institution Where the System is Implemented . . etc.
2. LEVEL	1. Reference Code, e.g.: 50,100,500,1000 (which corresponds to the cell resolution) 2. Spanish Title 3. English Title 4. Date of Latest Update 5. Cell Area, e.g.: 0.25,1,25,100 (in units of hectars) . . etc.
3. QUADRANT	1. Reference Code, e.g.: 1,2,3,...10 (Where Code 10 refers to the Oruro Quadrant) 2. Spanish Title 3. English Title 4. Date of Latest Update 5. Quadrant Corner Coordinates 6. Image Tape Number 7. Image File Number . . etc.
4. ELEMENT	1. Reference Code or Element Number 2. Spanish Title 3. English Title 4. Date of Latest Update 5. Document of Data Origin 6. Number of Fill Characters Used . . etc.

5. 1st SUB-ELEMENT	1. Reference Code 2. Spanish Title 3. English Title . . etc.
6. 2nd SUB-ELEMENT	1. Reference Code 2. Spanish Title 3. English Title . . etc.
7. 3rd SUB-ELEMENT	1. Reference Code 2. Spanish Title 3. English Title . . etc.

Tables 2 through 8 document the record data items and record formats of the Attribute Data Base. Table 9 contains a number of terms and their respective definitions. These terms are commonly used to describe an attribute data base.

Table 2. Attribute Data Base Record.

1.	ADBR Reference Code	I5
2.	Standard Header Line 1	132A1
3.	Standard Header Line 2	132A1
4.	Map Projection Name	32A1
5.	Principal Meridian	F4.1
6.	Standard Parallel 1	F4.1
7.	Standard Parallel 2	F4.1
8.	Pointer to First Level Record	I5
9.	Pointer to Next Attribute Data Base Record	I5
10.	Pointer to Parent Attribute Data Base Record	I5

Table 3. Level Record.

1. Level Reference Code.....I5
2. Spanish Level Name.....32A1
3. English Level Name.....32A1
4. Date of Last Level Updat (MM, DD, YY).....I2, I2, I2
5. Area of Pixel.....F6.2
6. Pointer to First Quadrant Record.....I5
7. Pointer to Next Level Record.....I5
8. Pointer to Parent Level Record
   (Attribute Data Base Record).....I5

Table 4. Quadrant Record.

1.	Quadrant Reference Code	I5
2.	Spanish Quadrant Name	32A1
3.	English Quadrant Name	32A1
4.	Date of Last Quadrant Update	I2, I2, I2
5.	Top Left Coordinate (LAT, LON, XA, YA)	2 (I3, 2I2), 2I5
6.	Top Right Coordinate (LAT, LON, XA, YA)	2 (I3, 2I2), 2I5
7.	Bottom Left Coordinate (LAT, LON, XA, YA)	2 (I3, 2I2), 2I5
8.	Bottom Right Coordinate (LAT, LON, XA, YA)	2 (I3, 2I2), 2I5
9.	Tape Number (Image Stored on)	I4
10.	File Number (Image Stored in)	I4
11.	Pointer to First Element Record	I5
12.	Pointer to Next Quadrant Record	I5
13.	Pointer to Parent Quadrant Record (Level Record)	I5

Table 5. Element Record.

1.	Element Reference Code	I5
2.	Spanish Element Name	32A1
3.	English Element Name	32A1
4.	Date of Last Element Update (MM, DD, YY)	I2, I2, I2
5.	History Document Data (Number, Last revision MM, YYYY)	I4, I2, I4
6.	Direct-Access Attribute Pointer	256I4
7.	Direct-Access Attribute Pointer File Descriptor	255I1
8.	Pointer to First Degree Description Record	I5
9.	Pointer to Next Element Record	I5
10.	Pointer to Parent Element record (Quadrant Record)	I5
11.	Pointer to Second Degree Description Record	I5
12.	Pointer to Third Degree Description Record	I5
13.	Extra Pointer	I5

Table 6. Generalized First Degree Description Record.

1. First Degree Description Reference Code.....I4
2. Spanish First Degree Description Name.....32A1
3. English First Degree Description Name.....32A1
4. Pointer to Second Degree Description Record.....I5
5. Pointer to next First Degree Description Record.....I5
6. Pointer to Parent First Degree Description Record (Element Record).....I5

Table 7. Generalized Second Degree Description Record.

1. Second Degree Description Reference Code.....I4
2. Spanish Second Degree Description Name.....32A1
3. English Second Degree Description Name.....32A1
4. Pointer to Third Degree Description Record.....I5
5. Pointer to Next Second Degree Description Record.....I5
6. Pointer to Parent Second Degree Description Record (First Degree Description Record).....I5

Table 8. Generalized Third Degree Description Record.

1. Third Degree Description Reference Code.....I4
2. Spanish Third Degree Description Name.....32A1
3. English Third Degree Description Name.....32A1
4. Pointer to Fourth Degree Description Record (Used for Possible Expansion).....I5
5. Pointer to Next Third Degree Description Record.....I5
6. Pointer to Parent Third Degree Description Record (Second Degree Description Record).....I5

Table 9. Definition of Terms Commonly Used in the Description of an Attribute Data Base.

Attribute	:	A field containing information about an entity.
Data Aggregate	:	A named collection of data items within a record.
Data Item	:	Smallest unit of named data.
Data Element	:	Synonymous with data item.
Data Set	:	Named collection of logically related data items.
Entity	:	Something about which data is stored.
File	:	A set of similarly constructed records.
Record	:	Named collection of data items or aggregates.
Set	:	Named collection of records.

Management Subsystem. The Management Subsystem of a digital GIS performs all the data handling operations; which include, among others, generation, interrogation and updating of data files (Salton, 1968). According to Thierauf (1975), the purpose of a data management subsystem is "to store, organize, and retrieve the required data to produce meaningful information." In the particular case of the Bolivian GIS, one of the primary functions of its data management subsystem is to carry out data handling operations between the Image Plane Data Base and the Attribute Data Base.

Modeling or Analysis Subsystem. This part of a digital GIS deals with the operations of extracting the data from storage (data base subsystem) and performing the analytical operations needed to meet the requirements of the problem at hand. For example, measurement of areas or calculation of distances, comparison of multiple data sets (between different data base elements), Boolean algebra operations, such as unions and intersections, up to extremely complex and sophisticated mathematical models that can be used for simulation and forecasting purposes.

Output Subsystem. Phillips (1978) stated that "the purpose of the output subsystem is actually twofold: it must produce both the products required by the system user and some intermediate products required by the data analyst. Typical outputs required by the system user include maps, tables, photographs, and digital magnetic tapes. The data analyst often needs the same products, but usually in a much less permanent form." Phillips also emphasizes that "careful attention should be given to the specification of the output products, for the system's effectiveness will be judged primarily on the ability of these products to provide the desired information in a useful format."

INPUT SUBSYSTEM'S USER DOCUMENTATION

The input subsystem of the Bolivian GIS consists of 1) a Map Input capability and 2) an Attribute Input capability.

This part of the report includes a detailed description of the procedure required to input both map and attribute (descriptive) data.

The schematic flow diagram of the Map Input Subsystem developed at Purdue/LARS for the Bolivian GIS was illustrated in Figure 4 of this report.

Basically, the Map Input subsystem includes the following processes:

1) Digitization
2) Editing
3) Coordinate Transformation
4) Rasterization

1) Map digitization is the process by which maps are transformed into computerized form, i.e. closed boundary lines (lines enclosing thematic units), linear features (rivers, roads, etc) and point data (intersection of geographic coordinates, mine locations, etc) are converted into a series of numerical values suitable for computer processing.

2) In order to determine the quality of the digitized maps, the digitized arcs, linear and point features are displayed for visual inspection. During this processing step, the digitized arc files can be edited, i.e., arcs are closed, added, or deleted. This process can be accomplished either through an automatic arc closure routine or by means of manual editing.

3) The relative numerical values resulting from the digitization process are first converted to a geographic coordinate system (latitude and longitude), and subsequently these coordinates are transformed to a preselected map projection. The Albers Equal Area Conical Projection was selected for the Bolivian GIS.

4) The last step in the Map Input subsystem consists of the rasterization process. During this process the map units are filled-in with pixels (cells) according to a predefined grid, and they are labeled with an identifier number (fill character). Figure 6 illustrates the different steps involved in the conversion of a polygonal file to a rasterized, gridded or cellular file.

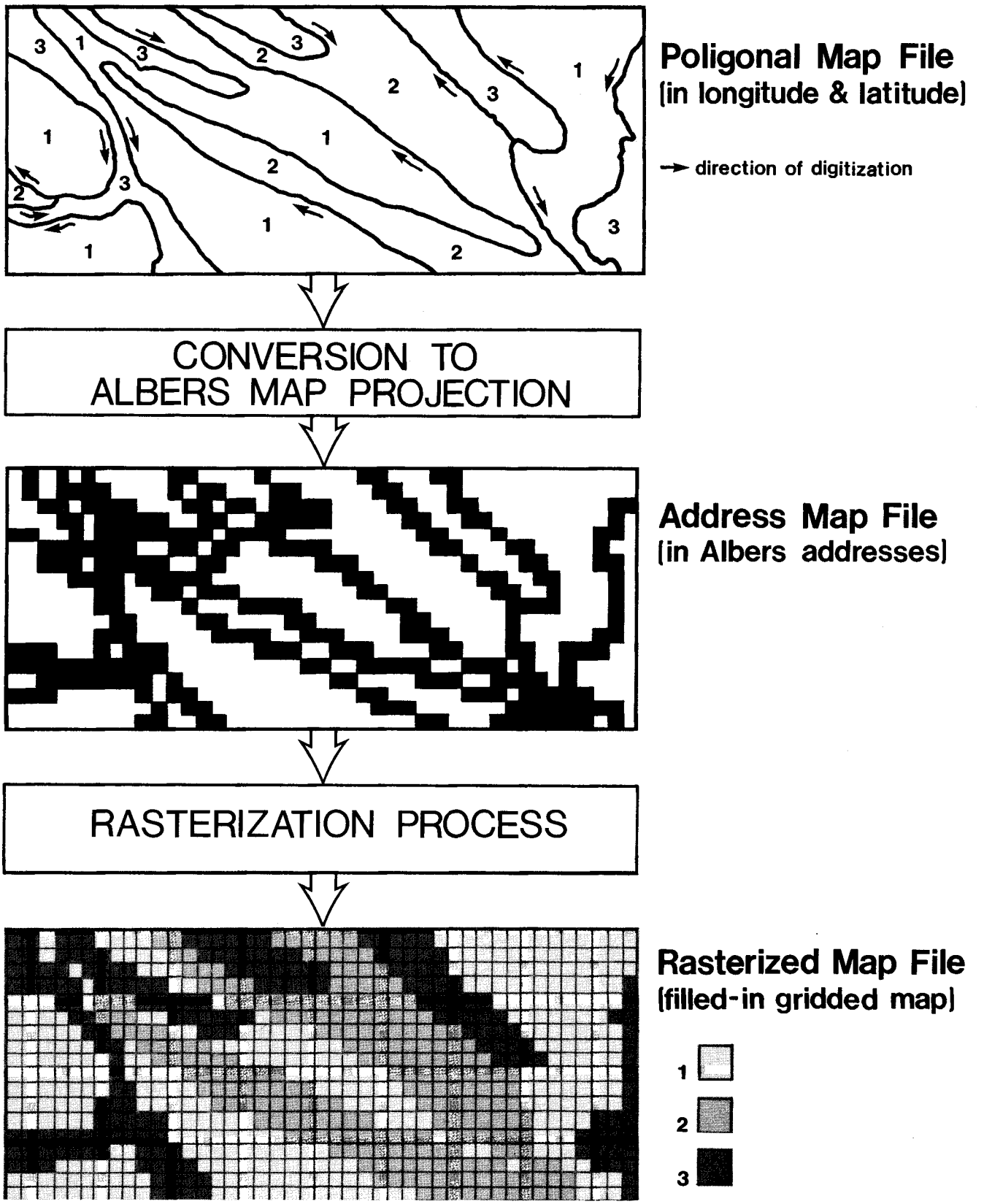

Figure 6. Steps Involved in the Conversion of a Polygonal Map File to a Rasterized (Cellular or Gridded) Map File

MAP INPUT PROCEDURE

Map Preparation

The first step in the process of map digitization involves the map preparation activity; that is, the maps to be digitized should be carefully examined in order to insure that all boundaries (polygons) are closed, and that all thematic units (areas enclosed by boundaries) are properly named or numbered. Once the maps are thoroughly verified and any doubtful situation properly resolved, the existing thematic units should be numbered according to the previously selected "fill characters" (ranging in value from 0 to 255), which correspond to the "thematic code" assigned to each of the units.

The next step involves the segmentation of the polygon boundaries into discrete arcs, each one having "beginning" and "ending" nodes, and "left-area" and "right-area" designations. These left and right area designations should correspond to the numerical values assigned to the thematic units. These concepts are illustrated in Figure 7.

In selecting left and right areas, or in other words, the direction of digitization (clockwise/counterclockwise), care should be taken in estimating the size and assesing the significance of the units; small and important units should always be digitized clockwise, so that the left area is assigned to the outside of the unit and the right area assigned to the inside as illustrated in Figure 7.

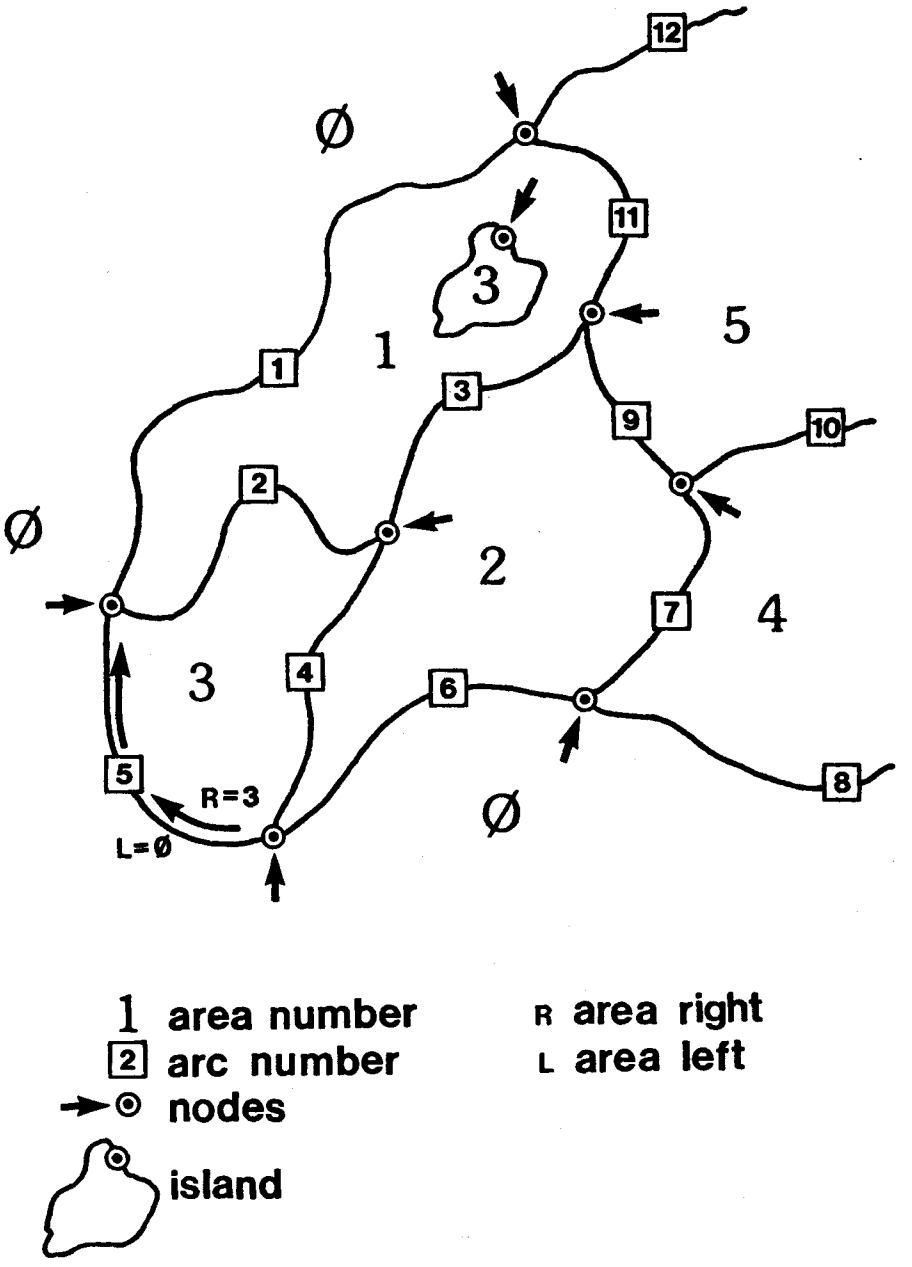

Figure 7. Basic Elements of a Resource Polygonal Map

If working with more than one map sheet, it is necessary to verify that all units present in two adjacent maps properly match, e.g., when mosaicking, boundary lines should form a continuum, with the same value assignations in both maps (same left and right areas in both).

It is recommended that before starting the digitizing process, a careful verification should be carried out to see if all the above steps have been completed and that the maps are clearly marked using a distinct color pencil with both, left and right area assignation, and direction of digitization.

Map Digitization

The procedure to digitize a map includes the following steps:

1. Login on a PDP terminal.
2. Start execution of digitization (RUN DIGIT).
3. Transfer digitized file (check, arc, and centroid files) from the PDP to the IBM main frame (@LITER).
4. Logoff from the PDP.

An example of a complete interactive map digitization process is given in the following pages. Note that the user's input is shown by the commands highlighted within boxes. The interactive capability of the digitizing system is based on a "command menu" approach as illustrated in the example below.

```
>HELLO
ACCOUNT OR ID: BOLGIS
PASSWORD:
ENTER NAME: LUIS

       RSX-11M BL26   MULTI-USER SYSTEM

GOOD NIGHT, WHAT ARE YOU DOING UP AT THIS HOUR?
04-NOV-81 00:05 LOGGED ON TERMINAL TT0:

00:05:38
LOGIN  USER BOLGIS          [277,1] TT0:
WELCOME TO RSX-11M

>RUN DIGIT




      04-NOV-81            LARS TABLE DIGITIZING SYSTEM          00:06:11
                                 VERSION 2.0
    ENTER FILENAME TO BE USED FOR DIGITIZED DATA (A6): BOLIV

    SET THE DIGITIZER TO POINT MODE--HIT RETURN WHEN SET

    INDICATE THE TOP LEFT CORNER WITH THE CURSOR

    INDICATE THE TOP RIGHT CORNER WITH THE CURSOR

    ENTER A COMMAND FROM THE FOLLOWING LIST
      ARC     -- TO START A NEW ARC
      LIN     -- TO START A LINEAR FEATURE
      RENUM   -- TO ENTER NEW ARC NUMBER
      POINT   -- TO ENTER POINT MODE
      TRACK   -- TO ENTER TRACK MODE
      TYPE    -- TO DISPLAY THE POINTS ON THE SCREEN
      NOTYPE  -- TO STOP THE DISPLAY ON THE SCREEN
      SIZE    -- TO CHANGE SMALLEST VECTOR ALLOWED
      CKPT    -- TO CREATE CHECK POINT FILE
      CENT    -- TO CREATE CENTROID FILE
      END     -- TO FINISH DIGITIZING SESSION
      CTRL/Z  -- TO CONTINUE DIGITIZING
?CKPT

    MAP SCALE = 1:250000

    ENTER LONG AND LAT CHECK POINTS IN DEG MIN SEC

    TYPE CTRL Z TO EXIT
    ENTER LONGITUDE: (D M S) 64 30 15
    ENTER LATITUDE: (D M S) 12 45 10
    MARK LONG,LAT CHECK POINT WITH CURSOR
  X =  342      Y =  571

    TYPE CTRL Z TO EXIT
    ENTER LONGITUDE: (D M S) 64 45 00
    ENTER LATITUDE: (D M S) 13 08 20
    MARK LONG,LAT CHECK POINT WITH CURSOR
  X =  413      Y = 1206

    TYPE CTRL Z TO EXIT
    ENTER LONGITUDE: (D M S) ^Z

    KEEP THIS CHECK POINT FILE? Y
```

```
   ENTER A COMMAND FROM THE FOLLOWING LIST
     ARC     -- TO START A NEW ARC
     LIN     -- TO START A LINEAR FEATURE
     RENUM   -- TO ENTER NEW ARC NUMBER
     POINT   -- TO ENTER POINT MODE
     TRACK   -- TO ENTER TRACK MODE
     TYPE    -- TO DISPLAY THE POINTS ON THE SCREEN
     NOTYPE  -- TO STOP THE DISPLAY ON THE SCREEN
     SIZE    -- TO CHANGE SMALLEST VECTOR ALLOWED
     CKPT    -- TO CREATE CHECK POINT FILE
     CENT    -- TO CREATE CENTROID FILE
     END     -- TO FINISH DIGITIZING SESSION
     CTRL/Z  -- TO CONTINUE DIGITIZING
?ARC
   ARC    1

     ENTER AREA ON LEFT: (CTRL Z TO EXIT) 0
     ENTER AREA ON RIGHT: (CTRL Z TO EXIT) 1

   SET THE DIGITIZER TO TRACK MODE--HIT RETURN WHEN SET

   ARC     1 MAY NOW BE DIGITIZED

   MARK ON RIGHT HAND SIDE OF TABLE OR
   PRESS THE BLANCO BUTTON
   WHEN YOU WANT TO GET TERMINAL'S ATTENTION,
   FOR ENTERING A COMMAND.

 2075   1112
 2097   1139
 2102   1142
 2139   1135


    *** FATAL READ ERROR FROM DIGITIZER ***
   LARGEST VECTOR IN LAST ARC =   0.49 INCHES
   KEEP LAST ARC? N
   ARC    1 HAS BEEN DELETED
   ARC    1

     ENTER AREA ON LEFT: (CTRL Z TO EXIT) 0
     ENTER AREA ON RIGHT: (CTRL Z TO EXIT) 1

   ARC     1 MAY NOW BE DIGITIZED

   MARK ON RIGHT HAND SIDE OF TABLE OR
   PRESS THE BLANCO BUTTON
   WHEN YOU WANT TO GET TERMINAL'S ATTENTION,
   FOR ENTERING A COMMAND.

 2088   1079
 2092   1079
 2104   1077
 2109   1075
 2115   1071
 2117   1069
 2119   1066
 2121   1060
 2122   1056
 2121   1052
 2117   1046
 2114   1043
 2110   1042
   LARGEST VECTOR IN LAST ARC =   0.14 INCHES
   KEEP LAST ARC? Y
```

```
    ARC    2

      ENTER AREA ON LEFT: (CTRL Z TO EXIT) 2
      ENTER AREA ON RIGHT: (CTRL Z TO EXIT) 1

    ARC     2 MAY NOW BE DIGITIZED

    MARK ON RIGHT HAND SIDE OF TABLE OR
    PRESS THE BLANCO BUTTON
    WHEN YOU WANT TO GET TERMINAL'S ATTENTION,
    FOR ENTERING A COMMAND.

  2109   1040
  2194   1040
  2112   1035
  2117   1031
  2125   1028
  2133   1027
  3922   2892
  2145   1032
  2147   1034
  2371   1034
    LARGEST VECTOR IN LAST ARC =  36.54 INCHES
    KEEP LAST ARC? Y
    ARC    3

      ENTER AREA ON LEFT: (CTRL Z TO EXIT) ^Z

    ENTER A COMMAND FROM THE FOLLOWING LIST
      ARC     -- TO START A NEW ARC
      LIN     -- TO START A LINEAR FEATURE
      RENUM   -- TO ENTER NEW ARC NUMBER
      POINT   -- TO ENTER POINT MODE
      TRACK   -- TO ENTER TRACK MODE
      TYPE    -- TO DISPLAY THE POINTS ON THE SCREEN
      NOTYPE  -- TO STOP THE DISPLAY ON THE SCREEN
      SIZE    -- TO CHANGE SMALLEST VECTOR ALLOWED
      CKPT    -- TO CREATE CHECK POINT FILE
      CENT    -- TO CREATE CENTROID FILE
      END     -- TO FINISH DIGITIZING SESSION
      CTRL/Z  -- TO CONTINUE DIGITIZING
?CENT

    SET THE DIGITIZER TO POINT MODE--HIT RETURN WHEN SET


    ENTER CENTROID DATA

    TYPE CTRL Z TO EXIT
    ENTER CODE FOR CENTROID(    1) 1
    MARK CENTROID WITH CURSOR

    TYPE CTRL Z TO EXIT
    ENTER CODE FOR CENTROID(    2) 2
    MARK CENTROID WITH CURSOR

    TYPE CTRL Z TO EXIT
    ENTER CODE FOR CENTROID(    3) ^Z

    ENTER A COMMAND FROM THE FOLLOWING LIST
      ARC     -- TO START A NEW ARC
      LIN     -- TO START A LINEAR FEATURE
      RENUM   -- TO ENTER NEW ARC NUMBER
      POINT   -- TO ENTER POINT MODE
      TRACK   -- TO ENTER TRACK MODE
      TYPE    -- TO DISPLAY THE POINTS ON THE SCREEN
      NOTYPE  -- TO STOP THE DISPLAY ON THE SCREEN
      SIZE    -- TO CHANGE SMALLEST VECTOR ALLOWED
      CKPT    -- TO CREATE CHECK POINT FILE
      CENT    -- TO CREATE CENTROID FILE
      END     -- TO FINISH DIGITIZING SESSION
      CTRL/Z  -- TO CONTINUE DIGITIZING
?END
CHARGE    001842659 2515     0.2111/ 4/81 FOR USER LUIS
SESSION TIME:     0.21 HOURS
DIGIT  --  STOP
```

```
PIP DB1:BOLIV.*/LI

DIRECTORY DB1:[277,1]
4-NOV-81 00:20

BOLIV.CKP;1          1.          04-NOV-81 00:11
BOLIV.DAT;1          1.          04-NOV-81 00:14
BOLIV.CEN;1          1.          04-NOV-81 00:17

TOTAL OF 3./30. BLOCKS IN 3. FILES


>@LITER
>* LITER [S]: XFER
>* IBM ID [S]: MAPPING
>* DO YOU WISH A HEADER READ CARD? [Y/N]:Y
>* FILE NAME [S]: DB1:BOLIV.CKP;1
>* IS THIS A BINARY FILE? [Y/N]:N
>PIP LITER.TMP/NV=LITER.TMP,DB1:BOLIV.CKP;1
PIP -- INPUT FILES HAVE CONFLICTING ATTRIBUTES
DB1:[277,1]BOLIV.CKP;1
>Tel Q=LITER.TMP
TEL -- 05-NOV-81 08:24:11 TOOLITER.TMP
TEL -- JOB SUCCESSFULLY QUEUED -- TELPRO IS * ACTIVE
>TEL .QON
>PIP LITER.TMP;*/DE
>* FILE NAME [S]: DB1:BOLIV.DAT;1
>* IS THIS A BINARY FILE? [Y/N]:N
>PIP LITER.TMP/NV=LITER.TMP,DB1:BOLIV.DAT;1
PIP -- INPUT FILES HAVE CONFLICTING ATTRIBUTES
DB1:[277,1]BOLIV.DAT;1
>Tel Q=LITER.TMP
TEL -- 05-NOV-81 08:25:05 TOOLITER.TMP
TEL -- JOB SUCCESSFULLY QUEUED -- TELPRO IS * ACTIVE
>TEL .QON
>PIP LITER.TMP;*/DE
>* FILE NAME [S]: DB1:BOLIV.CEN;1
>* IS THIS A BINARY FILE? [Y/N]:N
>PIP LITER.TMP/NV=LITER.TMP,DB1:BOLIV.CEN;1
PIP -- INPUT FILES HAVE CONFLICTING ATTRIBUTES
DB1:[277,1]BOLIV.CEN;1
>Tel Q=LITER.TMP
TEL -- 05-NOV-81 08:25:55 TOOLITER.TMP
TEL -- JOB SUCCESSFULLY QUEUED -- TELPRO IS * ACTIVE
>TEL .QON
>PIP LITER.TMP;*/DE
>* FILE NAME [S]:
>PIP LITER.TMP;*/DE
PIP -- NO SUCH FILE(S)
SY0:[277,1]LITER.TMP;*
>* LITER [S]: Q
>@ <EOF>


BYE
>
HAVE A NICE DAY
00:25:54
LOGOUT USER [277,1] TT0:
04-NOV-81 00:25 TT0:  LOGGED OFF
>
```

Once the digitized files have been transferred from the PDP to the IBM, the following procedural steps have to be accomplished:

1. Login on the IBM
2. Initialize CMS
3. Read the files sent from the PDP
4. Rename the file types*

PDP file type	change to	IBM file type
CKP	⟶	CHECK
DAT	⟶	DIGIT
CEN	⟶	CEN

5. Run the MAPPRO function, which is used to accomplish the following processes:
   a) automatic arc closure.
   b) coordinate conversion from relative x,y values to geographic coordinates.
   c) Projection transformation (ALBERS projection).
6. Run the RASCEN function, which is used for the rasterization of the address ALBERS files.

An example of an interactive procedure to complete the map digitizing process is given in the following pages. The input commands are shown by the lower cases letters.

---

* All three files must have the same file name.

```
VM/370 ONLINE
!

.l mappins database
ENTER NAME:.luis
LOGMSG - 08:52:29 EST THURSDAY 11/05/81
* YOUR LARS OPERATOR THIS MORNING IS PHIL HOFFER.
* NEXT SCHEDULED SHUTDOWN WILL BE FRI. 11/06/81 FROM 7:00 TO 9:00
* SAS 79.5 IS NOW THE DEFAULT VERSION OF SAS ON THE LARS SYSTEM.
* THE NEW BATCH SYSTEM IS NOW IN FULL PRODUCTION, AND ALL SUPPORT
* OF THE OLD BATCH SYSTEM HAS BEEN REMOVED FROM THE LARS SYSTEM.
* ANY JOBS SUBMITTED TO THE OLD BATCH SYSTEM WILL BE RETURNED TO THE
* USERS VIRTUAL READER.  COPIES OF THE BATCH 2.0 USERS MANUAL ARE
* AVAILABLE FROM OPERATIONS.
FILES: 003 RDR,  NO PRT,  NO PUN
LOGON AT 09:34:22 EST THURSDAY 11/05/81



 i cms
CMS  VM/BSE 2 613 06/12/81 07:15
.
Y (19E) R/O


You have no mail.
R; T=0.12/0.26 09:35:59

. read  * *
:READ BOLIV CKP A.
R; T=0.04/0.08 09:37:01

.read * *
:READ BOLIV:DA 1 A.
(NULL FILE).
R; T=0.02/0.04 09:37:10

.read *
:READ BOLIV DAT A.
R; T=0.04/0.06 09:37:21

.read * *
READER EMPTY OR NOT READY.
R(00008); T=0.02/0.03 09:37:29

.l read
FILE NOT FOUND
R(00028); T=0.02/0.03 09:38:10

.


 q read
NO RDR FILES
R; T=0.01/0.02 09:39:10

.rename boliv ckp a boliv check a
R; T=0.02/0.03 09:39:40

.rename boliv dat a boliv disit a
R; T=0.02/0.03 09:40:01
```

```
.l boliv * *
BOLIV    CEN       A1
BOLIV    CHECK     A1
BOLIV    DIGIT     A1
R; T=0.06/0.08 10:01:55

.mappro
*********************************************************************
*********************************************************************
***                                                               ***
***   M A P P R O  (MAP PROCESSING ROUTINES)                      ***
***                                                               ***
*** THIS IS A MULTI-STEP PROCESS.. PLEASE ENTER DATA REQUESTED     ***
***                                                               ***
***  PLEASE ENTER: INPUT FILENAME, FILETYPE, AND FUNCTION STEP     ***
***                                                               ***
***   WHERE:                                                      ***
***          FILENAME:  INPUT FILENAME OF DIGITIZED ARCS...       ***
***          FILETYPE:  INPUT FILETYPE OF DIGITIZED ARCS...       ***
***          FUNC.STEP: THE WORD 'SKIP' DATA ALREADY CLOSED...    ***
***                                                               ***
***   NOTICE:                                                     ***
***          YOU NEED TO HAVE:                                    ***
***                              1) CHECKPNT  (FILETYPE CHECK)    ***
***                              2) CENTROID FILE (FILETYPE CEN)  ***
***                                                               ***
*********************************************************************
*********************************************************************

.boliv digit

****************************************
****************************************
***                                  ***
***  PLEASE WAIT, COPY IN PROGRESS   ***
***                                  ***
****************************************
****************************************


*********************************************************************
*********************************************************************
***                                                               ***
***  C L O S U R E    R O U T I N E    S T A R T E D              ***
***                                                               ***
*********************************************************************
*********************************************************************

 ***************************************************
 ***************************************************
 ***                                             ***
 ***  PLEASE ENTER A CLOSURE DISTANCE IN INCHES.  ***
 ***                                             ***
 ***  (.25 IS SUGGESTED... HIT RETURN TO END )   ***
 ***                                             ***
 ***************************************************
 ***************************************************
..5
 ****************************************
 ****************************************
 ***                                  ***
 *** A CLOSURE REPORT IS BEING PRINTED ***
 ***                                  ***
 ****************************************
 ****************************************
```

```
##################################################
##################################################
###                                            ###
###  WOULD YOU LIKE TO EXIT PROMAP INORDER TO  ###
###  RUN TO EDITMAP ROUTINE?? (YES,NO)         ###
###                                            ###
##################################################
##################################################

.no

######################################################################
######################################################################
###                                                                ###
###   X - Y   T O   L O N G I T U D E - L A T I T U D E  ....      ###
###                                                                ###
###            T R A N S F O R M A T I O N                         ###
###                                                                ###
###                    P R O C E S S                               ###
###                                                                ###
######################################################################
######################################################################

 ##################################################
 ##################################################
 ###                                            ###
 ###   PLEASE ENTER MAXIMUM PIXEL ERROR ALLOWED ###
 ###                                            ###
 ##################################################
 ##################################################

?
.1

 ##################################################
 ##################################################
 ###                                            ###
 ###   ALBERS PROJECTION SELECTION.....         ###
 ###                                            ###
 ##################################################
 ##################################################

 (  1) BOLIVIA

 => PICK THE NUMBER OF THE AREA YOU WISH TO PROJECT
?
.1
 ##################################################
 ##################################################
 ###                                            ###
 ###  WITH A MAPPING SCALE OF   250000.000      ###
 ###  THE PROPOSED GRIDDING FACTOR IS  500.0    ###
 ###                                            ###
 ###  PLEASE ENTER A NEW GRIDDING FACTOR, OR    ###
 ###  HIT THE RETURN KEY TO KEEP THE SAME....   ###
 ###                                            ###
 ##################################################
 ##################################################
?
.

 STANDARD DEVIATION OF ALBERS ADDRESSING ERROR :    0.076762
```

```
##############################################
##############################################
###                                        ###
###   S T A R T   P R O J E C T I O N S    ###
###                                        ###
##############################################
##############################################


######################################################################
######################################################################
###                                                                ###
###  CONVERTING LONGITUDE - LATITUDE OF ARC INFO. TO ALBERS        ###
###                                                                ###
######################################################################
######################################################################


 ################################################
 ################################################
 ###                                          ###
 ###   ALBERS PROJECTION SELECTION.....       ###
 ###                                          ###
 ################################################
 ################################################

 (  1) BOLIVIA

 => PICK THE NUMBER OF THE AREA YOU WISH TO PROJECT
?
.1
 ################################################
 ################################################
 ###                                          ###
 ###  WITH A MAPPING SCALE OF   250000.000    ###
 ###  THE PROPOSED GRIDDING FACTOR IS  500.0  ###
 ###                                          ###
 ###  PLEASE ENTER A NEW GRIDDING FACTOR, OR  ###
 ###  HIT THE RETURN KEY TO KEEP THE SAME....  ###
 ###                                          ###
 ################################################
 ################################################
?
.


######################################################################
######################################################################
###                                                                ###
###  CONVERTING LONGITUDE - LATITUDE OF CENTROID TO ALBERS          ###
###                                                                ###
######################################################################
######################################################################


 ################################################
 ################################################
 ###                                          ###
 ###   ALBERS PROJECTION SELECTION.....       ###
 ###                                          ###
 ################################################
 ################################################

 (  1) BOLIVIA

 => PICK THE NUMBER OF THE AREA YOU WISH TO PROJECT
?
.1
```

```
**************************************************
**************************************************
***                                            ***
***  WITH A MAPPING SCALE OF   250000.000      ***
***  THE PROPOSED GRIDDING FACTOR IS  500.0    ***
***                                            ***
***  PLEASE ENTER A NEW GRIDDING FACTOR, OR    ***
***  HIT THE RETURN KEY TO KEEP THE SAME....   ***
***                                            ***
**************************************************
**************************************************
?
.


******************************************
******************************************
***                                    ***
***   S U C C E S S F U L    R U N     ***
***                                    ***
******************************************
******************************************

FILENAME FILETYPE  FM  FORMAT   RECS  BLKS    DATE     TIME    LABEL
BOLIV    ADDR      A1  F    80   501    40  11/05/81 10.08.57  MAPING
BOLIV    CEN       A1  F    80    28     3  11/05/81 10.01.41  MAPING
BOLIV    CENT      A1  F    80    28     3  11/05/81 10.10.01  MAPING
BOLIV    CHECK     A1  F    80    22     2  11/05/81 10.01.04  MAPING
BOLIV    DIGIT     A1  F    80   633    50  11/05/81 10.01.27  MAPING
BOLIV    LONCEN    A1  F    80    29     3  11/05/81 10.07.23  MAPING
BOLIV    LONLAT    A1  F    80   956    75  11/05/81 10.07.23  MAPING
R; T=23.01/27.02 10:10:36
```

```
.rascen
LARSLIB  29C HAS BEEN ATTACHED AS 29C.
DMSACC724I '29C' REPLACES ' N (29C) '
DMSACC723I N (29C) R/O
29C HAS BEEN ACCESSED AS N   DISK.


   ************************************************************
   ************************************************************
   ***                                                      ***
   ***    R A S T E R I Z A T I O N   R O U T I N E         ***
   ***                                                      ***
   ***     ( F O R   C E N T R O I D   M E T H O D )        ***
   ***                                                      ***
   ***   THE CENTROID RASTER METHOD MUST PLACE THE RASTER   ***
   ***   IMAGE TEMPORARILY OUT TO A TEMP DISK... THIS TAKES ***
   ***   UP SPACE. TO INSURE THAT AN IMAGE OF OVER 1000 LINES ***
   ***   CAN BE SUCCESSFULLY RASTERIZED, IT IS NECESSARY TO ***
   ***   DEFINE A LARGE TEMP DISK.....                      ***
   ***                                                      ***
   ***    DO YOU BELIEVE THE IMAGE WILL BE OVER 1000 LINES??? ***
   ***                                                      ***
   ************************************************************
   ************************************************************

    YES OR NO ?
.no
DMSARE069E DISK '196' NOT ACCESSED.
DMKVDD040E DEV 196 DOES NOT EXIST
TEMP     271 HAS BEEN ATTACHED AS 196.  (003.00 MEGABYTES)
196 HAS BEEN ACCESSED AS B   DISK.


************************************************************
************************************************************
***                                                      ***
***   THE RASTER PROGRAM ALSO REQUIRES A GREAT DEAL OF   ***
***   CORE IN ORDER TO FUNCTION..   IF THIS ID IS NOT    ***
***   SET UP AS A 2 MEGA-BYTE MACHINE PLEASE TYPE THE    ***
***   THE WORD 'STOP' AT THE NEXT DATA REQUEST.....      ***
***                                                      ***
***  PLEASE ENTER THE FN,FT,AND FM OF THE INPUT FILE TO  ***
***  BE RASTERIZED....                                   ***
***                                                      ***
************************************************************
************************************************************

.stop
R; T=0.20/0.69 10:12:39

.CP
.define stor 2m
STORAGE = 02048K
.i cms
CMS  VM/BSE 2 613 06/12/81 07:15
.
DMSACC723I Y (19E) R/O
DMSINS100W CMSZER SYSTEM NAME 'CMSZER' NOT AVAILABLE.
DMSINS100W CMSSEG SYSTEM NAME 'CMSSEG' NOT AVAILABLE.

You have no mail.
R; T=0.14/0.33 10:13:28
```

```
.rascen
LARSLIB  29C HAS BEEN ATTACHED AS 29C.
DMSACC723I N (29C) R/O
29C HAS BEEN ACCESSED AS N   DISK.


   ************************************************************
   ************************************************************
   ***                                                      ***
   ***    R A S T E R I Z A T I O N   R O U T I N E         ***
   ***                                                      ***
   ***     ( F O R   C E N T R O I D   M E T H O D )        ***
   ***                                                      ***
   ***   THE CENTROID RASTER METHOD MUST PLACE THE RASTER   ***
   ***   IMAGE TEMPORARILY OUT TO A TEMP DISK... THIS TAKES ***
   ***   UP SPACE. TO INSURE THAT AN IMAGE OF OVER 1000 LINES ***
   ***   CAN BE SUCCESSFULLY RASTERIZED, IT IS NECESSARY TO ***
   ***   DEFINE A LARGE TEMP DISK.....                      ***
   ***                                                      ***
   ***    DO YOU BELIEVE THE IMAGE WILL BE OVER 1000 LINES??? ***
   ***                                                      ***
   ************************************************************
   ************************************************************

    YES OR NO ?
.no
DMSARE069E DISK '196' NOT ACCESSED.
DASD 196 DETACHED
TEMP     156 HAS BEEN ATTACHED AS 196.  (003.00 MEGABYTES)
196 HAS BEEN ACCESSED AS B   DISK.


************************************************************
************************************************************
***                                                      ***
***   THE RASTER PROGRAM ALSO REQUIRES A GREAT DEAL OF   ***
***   CORE IN ORDER TO FUNCTION..   IF THIS ID IS NOT    ***
***   SET UP AS A 2 MEGA-BYTE MACHINE PLEASE TYPE THE    ***
***   THE WORD 'STOP' AT THE NEXT DATA REQUEST.....      ***
***                                                      ***
***  PLEASE ENTER THE FN,FT,AND FM OF THE INPUT FILE TO  ***
***  BE RASTERIZED....                                   ***
***                                                      ***
************************************************************
************************************************************

.boliv addr a
DMSLIO740I EXECUTION BEGINS...


 ************************************************
 ***                                          ***
 ***  RASTER FILL ROUTINE: (CENTROID METHOD)  ***
 ***                                          ***
 ***  PLEASE ENTER THE FOLLOWING INFORMATION  ***
 ***  ABOUT THE OUTPUT DATA TAPE:             ***
 ***                                          ***
 ************************************************
 ************************************************
```

```
 ####################################
 ####################################
 ###                              ###
 ###  ENTER THE OUTPUT TAPE NUMBER ###
 ###                              ###
 ####################################
 ####################################
?
.9999
 ####################################
 ####################################
 ###                              ###
 ###  ENTER THE OUTPUT FILE NUMBER ###
 ###                              ###
 ####################################
 ####################################
?
.1
 ###################################
 ###################################
 ###                             ###
 ### ENTER A LARSYS RUN NUMBER   ###
 ###                             ###
 ###################################
 ###################################
?
.81110501
 ####################################
 ####################################
 ###                              ###
 ### RASTER LINEAR FEATURES???    ###
 ###    (1) YES                   ###
 ###    (2) NO                    ###
 ###                              ###
 ####################################
 ####################################
?
.no
 ####################################
 ####################################
 ###                              ###
 ### RASTER LINEAR FEATURES???    ###
 ###    (1) YES                   ###
 ###    (2) NO                    ###
 ###                              ###
 ####################################
 ####################################
?
.2
```

```
##########################################
##########################################
###                                    ###
###  IS THE FOLLOWING INFORMATION RIGHT? ###
###                                    ###
###   OUTPUT TAPE: 9999                ###
###   OUTPUT FILE:    1                ###
###   OUTPUT RUN NUMBER: 81110501      ###
###   LINEAR FEATURES FLAG: 2 WHERE:   ###
###       (1) CREATE LINEAR FEATURES   ###
###       (2) IGNORE LINEAR FEATURES   ###
###                                    ###
###   ENTER:: (1) INPUTS OK...         ###
###   ENTER:: (2) INPUTS WRONG...      ###
###                                    ###
##########################################
##########################################
?
.1

##############################
##############################
##                          ##
## BEGINNING TO READ IN ARCS ##
##                          ##
##############################
##############################
### NOW WORKING ON ARC NUMBER   1 ###
### NOW WORKING ON ARC NUMBER   2 ###
### NOW WORKING ON ARC NUMBER   3 ###
### NOW WORKING ON ARC NUMBER   4 ###
### NOW WORKING ON ARC NUMBER   5 ###
### NOW WORKING ON ARC NUMBER   6 ###
### NOW WORKING ON ARC NUMBER   7 ###
### NOW WORKING ON ARC NUMBER   8 ###
### NOW WORKING ON ARC NUMBER   9 ###
### NOW WORKING ON ARC NUMBER  10 ###
### NOW WORKING ON ARC NUMBER  11 ###
### NOW WORKING ON ARC NUMBER  12 ###
### NOW WORKING ON ARC NUMBER  13 ###
### NOW WORKING ON ARC NUMBER  14 ###
### NOW WORKING ON ARC NUMBER  15 ###
### NOW WORKING ON ARC NUMBER  16 ###
### NOW WORKING ON ARC NUMBER  17 ###
### NOW WORKING ON ARC NUMBER  18 ###
### NOW WORKING ON ARC NUMBER  19 ###
### NOW WORKING ON ARC NUMBER  20 ###
### NOW WORKING ON ARC NUMBER  21 ###
### NOW WORKING ON ARC NUMBER  22 ###
### NOW WORKING ON ARC NUMBER  23 ###
### NOW WORKING ON ARC NUMBER  24 ###
### NOW WORKING ON ARC NUMBER  25 ###
### NOW WORKING ON ARC NUMBER  26 ###
### NOW WORKING ON ARC NUMBER  27 ###
### NOW WORKING ON ARC NUMBER  28 ###
### NOW WORKING ON ARC NUMBER  29 ###
### NOW WORKING ON ARC NUMBER  30 ###
### NOW WORKING ON ARC NUMBER  31 ###
### NOW WORKING ON ARC NUMBER  32 ###
### NOW WORKING ON ARC NUMBER  33 ###
### NOW WORKING ON ARC NUMBER  34 ###
### NOW WORKING ON ARC NUMBER  35 ###
```

```
*********************************************
*********************************************
***                                       ***
*** BEGINNING TO SORT:  2059 ITEMS         ***
***                                       ***
*********************************************
*********************************************
*********************************************
*********************************************
***                                       ***
***  PROCESSING AREA MAPPING FEATURES     ***
***                                       ***
*********************************************
*********************************************
***    18 OF   188 LINES INITIALLY FILLED ***
***    36 OF   188 LINES INITIALLY FILLED ***
***    54 OF   188 LINES INITIALLY FILLED ***
***    72 OF   188 LINES INITIALLY FILLED ***
***    90 OF   188 LINES INITIALLY FILLED ***
***   108 OF   188 LINES INITIALLY FILLED ***
***   126 OF   188 LINES INITIALLY FILLED ***
***   144 OF   188 LINES INITIALLY FILLED ***
***   162 OF   188 LINES INITIALLY FILLED ***
***   180 OF   188 LINES INITIALLY FILLED ***
***                                       ***
***    18 OF   188 LINES CENTROID FILLED  ***
***    36 OF   188 LINES CENTROID FILLED  ***
***    54 OF   188 LINES CENTROID FILLED  ***
***    72 OF   188 LINES CENTROID FILLED  ***
***    90 OF   188 LINES CENTROID FILLED  ***
***   108 OF   188 LINES CENTROID FILLED  ***
***   126 OF   188 LINES CENTROID FILLED  ***
***   144 OF   188 LINES CENTROID FILLED  ***
***   162 OF   188 LINES CENTROID FILLED  ***
***   180 OF   188 LINES CENTROID FILLED  ***
*********************************************
*********************************************
```

```
E N D I N G   S T A T I S T I C S . . . . .

NUMBER OF LINES RASTERIZED :                188
NUMBER OF SAMPLES RASTERIZED :              300
STARTING LINE OF IMAGE :                   2092
STARTING SAMPLE OF IMAGE :                  308
NUMBER OF ARCS ENCOUNTERED                   35
NUMBER OF ARC POINTS                       2059
AVERAGE NUMBER OF ARC POINTS                 58
TOTAL NUMBER OF PIXELS NON-ZERO FILLED     36171
OUTPUT TAPE NUMBER:                         9999
OUTPUT TAPE FILE:                              1
OUTPUT LARSYS RUN NUMBER:               81110501
NUMBER OF CHANNELS ON OUTPUT TAPE:             2
```

```
 ************************************************
 ************************************************
 ***                                          ***
 ***  NO LINEAR FEATURES ENCOUNTERED IN ARCS  ***
 ***                                          ***
 ************************************************
 ************************************************
 I0002 TAPE 9999 HAS BEEN REQUESTED ON UNIT 181    (TAPMOUNT)
TAPE 181 ATTACHED
 I0003 TAPE READY...    EXECUTION CONTINUING    (TAPMOUNT)
 ***   100 OF   188 LINES WRITTEN TO TAPE  ***
 ************************************************
 ************************************************
 ***                                          ***
 ***  DO YOU WISH TO HAVE A CDISPLAY DECK     ***
 ***  CREATED FOR THIS IMAGE?                 ***
 ***  (ENTER A NUMBER: 1 OR 2 WHERE)          ***
 ***     (1) YES                              ***
 ***     (2) NO                               ***
 ***                                          ***
 ************************************************
 ************************************************
?
.2
TAPE 181 DETACHED
R; T=27.53/33.51 10:28:35

.
```

Descriptive (Attribute) Data Input

In order to insert the descriptive or attribute data into the Attribute Data Base and to quary this data base, an interactive procedure is used as illustrated in the following example. Note that the user's input is shown by the lower case commands.

```
VM/370 ONLINE
!

.l insert database
ENTER NAME:.carlos
LOGMSG - 13:01:27 EST THURSDAY 11/05/81
* YOUR LARS OPERATORS ARE DAVID KEMPF AND JERRY URBANUS.
* NEXT SCHEDULED SHUTDOWN WILL BE FRI. 11/06/81 FROM 7:00 TO 9:00
* SAS 79.5 IS NOW THE DEFAULT VERSION OF SAS ON THE LARS SYSTEM.
* THE NEW BATCH SYSTEM IS NOW IN FULL PRODUCTION, AND ALL SUPPORT
* OF THE OLD BATCH SYSTEM HAS BEEN REMOVED FROM THE LARS SYSTEM.
* ANY JOBS SUBMITTED TO THE OLD BATCH SYSTEM WILL BE RETURNED TO THE
* USERS VIRTUAL READER.  COPIES OF THE BATCH 2.0 USERS MANUAL ARE
* AVAILABLE FROM OPERATIONS.
LOGON AT 13:41:31 EST THURSDAY 11/05/81

.i cms
CMS  VM/BSE 2 613 06/12/81 07:15
.
Y (19E) R/O


You have no mail.
EXECUTION BEGINS...


 ************************************************************
 ***                                                      ***
 ***                                          11/ 5/81    ***
 ***                                                      ***
 ***    G E O G R A P H I C     I N F O R M A T I O N     ***
 ***                                                      ***
 ***     D A T A   M A N A G E M E N T   S Y S T E M      ***
 ***                                                      ***
 ***    LATEST SYSTEM UPDATE:  SEPTEMBER 23, 1981         ***
 ***                                                      ***
 ***    DAVID L. SNYDER                                   ***
 ***    APPLICATIONS PROGRAMMER I                         ***
 ***    L.A.R.S.                                          ***
 ***    PURDUE UNIVERSITY                                 ***
 ***                                                      ***
 ************************************************************
 ************************************************************

 PLEASE ENTER THE PRIVELEDGE OPERATOR ID (IF KNOWN)
.cva


************************************************************************
************************************************************************
***                                                                  ***
***  TO WHOM IT MAY CONCERN (CARLOS)                                 ***
***                                                                  ***
***      WE HAVE A COUPLE OF NEW FUNCTIONS:::                        ***
***                                                                  ***
***         SAVE  AND  RESTORE                                       ***
***     SAVE DOES THE SAME THING AS A BACKUP....                     ***
***     RESTORE RESETS THE DATABASE TO THE STATE AFTER LAST BACKU    ***
***                                                                  ***
***    I HAVE ALREADY DONE ONE DUMP (SAVE) FOR YOU                   ***
***    SO YOU OUGHT TO DO ONE AFTER YOU MAKE A BUNCH OF CHANGES..    ***
***                                                                  ***
***                                       GOOD LUCK...               ***
***                                       DAVE SNYDER                ***
***                                                                  ***
************************************************************************
************************************************************************
IH0001A PAUSE  *** HIT RETURN TO CONTINUE ***
.
```

```
CMD>
.help

VAILABLE DATABASE MGMT SYSTEM COMMANDS:::

  (NR) MEANS NOT RESTRICTED COMMAND...
  (RE) MEANS RESTRICTED TO PRIVELEDGED USERS...

  BACK(NR)      CHANGE(RE)    DELETE(RE)    DOWN(NR)
  DUMP(NR)      ELEMENT(NR)   FILE(NR)      HELP(NR)
  INSERT(RE)    LOCATE(NR)    MERGE(RE)     NEXT(NR)
  PARENT(NR)    RESTORE(RE)   SAVE(RE)      STOP(NR)
  SYNTAX(NR)    TROUBLE(NR)   TYPE(NR)      UP(NR)
  =(NR)         ?(NR)         MAP(NR)


MD>
.1 500
 LEVEL REFERENCE CODE:    500

     SPANISH TITLE


     ENGLISH TITLE
          DEPARTMENTAL

     DATE LAST UPDATED
          11/ 2/81

     AREA PER PIXEL (HECTARES)
            1.25


CMD>
.1 500 10
QUADRANT REFERENCE CODE:     10
     SPANISH TITLE
          ORURO
     ENGLISH TITLE
          ORURO
     DATE LAST UPDATED
          11/ 2/81
     IMAGE COORDINATES
     TOP LEFT                    TOP RIGHT

 LON       0     0     0        LON       0     0     0
 LAT       0     0     0        LAT       0     0     0
   X     100     Y 1600         X     999     Y 1600

    BOTTOM LEFT                 BOTTOM RIGHT

 LON       0     0     0        LON       0     0     0
 LAT       0     0     0        LAT       0     0     0
   X     100     Y 2499         X     999     Y 2499

     IMAGE TAPE NUMBER:       0  IMAGE FILE NUMBER:       0

CMD>
.1 500 10 4
ELEMENT CODE:      4

     SPANISH TITLE


     ENGLISH TITLE
          POLITICAL BOUNDARIES

     DATE LAST UPDATED
          9/23/81

     DATA HISTORY DOCUMENT
          NUMBER:     0 MONTH:     0 YEAR:     0

THERE ARE:    0 FILL CHARACTERS ASSIGNED
```

```
CMD>
.b
ELEMENT CODE:      4

     SPANISH TITLE


     ENGLISH TITLE
          POLITICAL BOUNDARIES

     DATE LAST UPDATED
          9/23/81

     DATA HISTORY DOCUMENT
          NUMBER:    0 MONTH:    0 YEAR:    0

THERE ARE:   0 FILL CHARACTERS ASSIGNED


CMD>
.n
ELEMENT CODE:      8

     SPANISH TITLE
          COBERTURA Y USO DE LA TIERRA

     ENGLISH TITLE
          LAND COVER AND LAND USE

     DATE LAST UPDATED
          11/ 2/81

     DATA HISTORY DOCUMENT
          NUMBER:    1 MONTH:   11 YEAR:   81

THERE ARE:  25 FILL CHARACTERS ASSIGNED


CMD>
.n
ELEMENT CODE:      9

     SPANISH TITLE
          SUELOS

     ENGLISH TITLE
          SOILS

     DATE LAST UPDATED
          11/ 2/81

     DATA HISTORY DOCUMENT
          NUMBER:    1 MONTH:   11 YEAR:   81

THERE ARE:   0 FILL CHARACTERS ASSIGNED
```

```
ELEMENT CODE:      4

     SPANISH TITLE


     ENGLISH TITLE
          POLITICAL BOUNDARIES

     DATE LAST UPDATED
           9/23/81

     DATA HISTORY DOCUMENT
          NUMBER:    0 MONTH:    0 YEAR:    0

THERE ARE:   0 FILL CHARACTERS ASSIGNED


CMD>
.change title
 => ENTER TITLE TYPE(SPANISH OR ENGLISH)
.spanish
 => PLEASE ENTER REVISED SPANISH NAME
.limites politicos
CMD>

CMD>
.b
QUADRANT REFERENCE CODE:     10
     SPANISH TITLE
          ORURO
     ENGLISH TITLE
          ORURO
     DATE LAST UPDATED
          11/ 5/81
     IMAGE COORDINATES
     TOP LEFT                  TOP RIGHT

 LON       0     0     0       LON       0    0    0
 LAT       0     0     0       LAT       0    0    0
   X     100    Y 1600          X     999    Y 1600

    BOTTOM LEFT                BOTTOM RIGHT

 LON       0     0     0       LON       0    0    0
 LAT       0     0     0       LAT       0    0    0
   X     100    Y 2499          X     999    Y 2499

     IMAGE TAPE NUMBER:      0  IMAGE FILE NUMBER:      0

CMD>
.d
ELEMENT CODE:      4

     SPANISH TITLE
          LIMITES POLITICOS

     ENGLISH TITLE
          POLITICAL BOUNDARIES

     DATE LAST UPDATED
          11/ 5/81

     DATA HISTORY DOCUMENT
          NUMBER:    0 MONTH:    0 YEAR:    0

THERE ARE:   0 FILL CHARACTERS ASSIGNED


CMD>
```

```
CMD>
.d
 COUNTRY REFERENCE CODE:     1

     SPANISH COUNTRY TITLE
          BOLIVIA

     ENGLISH COUNTRY TITLE
          BOLIVIA
CMD>
.d
 DEPARTMENT REFERENCE CODE:     1

     SPANISH DEPARTMENT TITLE
          CHUQUISACA
CMD>
.n
 DEPARTMENT REFERENCE CODE:     2

     SPANISH DEPARTMENT TITLE
          LA PAZ
CMD>
.n
 DEPARTMENT REFERENCE CODE:     3

     SPANISH DEPARTMENT TITLE
          COCHABAMBA
CMD>
.n
 DEPARTMENT REFERENCE CODE:     4

     SPANISH DEPARTMENT TITLE
          ORURO
CMD>
.n
 DEPARTMENT REFERENCE CODE:     5

     SPANISH DEPARTMENT TITLE
          POTOSI
CMD>
.n
 DEPARTMENT REFERENCE CODE:     6

     SPANISH DEPARTMENT TITLE
          TARIJA
CMD>
.n
 DEPARTMENT REFERENCE CODE:     7

     SPANISH DEPARTMENT TITLE
          SANTA CRUZ
CMD>
.n
 DEPARTMENT REFERENCE CODE:     8

     SPANISH DEPARTMENT TITLE
          BENI
CMD>
.n
 DEPARTMENT REFERENCE CODE:     9

     SPANISH DEPARTMENT TITLE
          PANDO
CMD>
```

```
.b
 DEPARTMENT REFERENCE CODE:     8

     SPANISH DEPARTMENT TITLE
          BENI
CMD>
.P
 COUNTRY REFERENCE CODE:     1

     SPANISH COUNTRY TITLE
          BOLIVIA

     ENGLISH COUNTRY TITLE
          BOLIVIA
CMD>
.d
 DEPARTMENT REFERENCE CODE:     1

     SPANISH DEPARTMENT TITLE
          CHUQUISACA
CMD>
.n
 DEPARTMENT REFERENCE CODE:     2

     SPANISH DEPARTMENT TITLE
          LA PAZ
CMD>
.n
 DEPARTMENT REFERENCE CODE:     3

     SPANISH DEPARTMENT TITLE
          COCHABAMBA
CMD>
.n
 DEPARTMENT REFERENCE CODE:     4

     SPANISH DEPARTMENT TITLE
          ORURO
CMD>
.d
 PROVINCE REFERENCE CODE:    43

     SPANISH PROVINCE TITLE
          CERCADO
CMD>
.d
 ************************************************
 ************************************************
 ***                                          ***
 *** NO 4TH SUB-ELEMENT FOR 3RD SUB-ELE.     43 ***
 ***                                          ***
 ************************************************
 ************************************************
IH0001A PAUSE   *** PLEASE HIT RETURN TO CONTINUE ***
.
 PROVINCE REFERENCE CODE:    43

     SPANISH PROVINCE TITLE
          CERCADO
CMD>
```

```
.i
 ##################################################
 ##################################################
 ###                                            ###
 ###  PLEASE ENTER A NUMBER (1-2) WHERE:        ###
 ###                                            ###
 ###    (1)  INSERT RECORD ON SAME LEVEL        ###
 ###    (2)  INSERT RECORD ONE LEVEL DOWN       ###
 ###    (CR) END INSERT AND RETURN TO CMD...    ###
 ###                                            ###
 ##################################################
 ##################################################
.2
 => ENTER 4TH SUB-ELEMENT REFERENCE CODE
?
.1
 => ENTER 4TH SUB-ELEMENT SPANISH TITLE
.caracollo
 => ENTER 4TH SUB-ELEMENT ENGLISH TITLE (*SPANISH*)
.caracollo
 ##################################################
 ##################################################
 ###                                            ###
 ###  PLEASE ENTER A NUMBER (1-2) WHERE:        ###
 ###                                            ###
 ###    (1)  INSERT RECORD ON SAME LEVEL        ###
 ###    (CR) END INSERT AND RETURN TO CMD...    ###
 ###                                            ###
 ##################################################
 ##################################################
.1
 => ENTER 4TH SUB-ELEMENT REFERENCE CODE
?
.2
 => ENTER 4TH SUB-ELEMENT SPANISH TITLE
.crucero del belen
 => ENTER 4TH SUB-ELEMENT ENGLISH TITLE (*SPANISH*)
.crucero del belen
 ##################################################
 ##################################################
 ###                                            ###
 ###  PLEASE ENTER A NUMBER (1-2) WHERE:        ###
 ###                                            ###
 ###    (1)  INSERT RECORD ON SAME LEVEL        ###
 ###    (CR) END INSERT AND RETURN TO CMD...    ###
 ###                                            ###
 ##################################################
 ##################################################
.1
 => ENTER 4TH SUB-ELEMENT REFERENCE CODE
?
.3
 => ENTER 4TH SUB-ELEMENT SPANISH TITLE
.bella vista
 => ENTER 4TH SUB-ELEMENT ENGLISH TITLE (*SPANISH*)
.bella bista
 ##################################################
 ##################################################
 ###                                            ###
 ###  PLEASE ENTER A NUMBER (1-2) WHERE:        ###
 ###                                            ###
 ###    (1)  INSERT RECORD ON SAME LEVEL        ###
 ###    (CR) END INSERT AND RETURN TO CMD...    ###
 ###                                            ###
 ##################################################
 ##################################################

CMD>
```

```
.b
 PROVINCE REFERENCE CODE:    43

     SPANISH PROVINCE TITLE
          CERCADO
CMD>
.d
 CANTON REFERENCE CODE:     1

      CANTON SPANISH TITLE
          CARACOLLO
CMD>
.change fill
 => PLEASE ENTER REVISED FILL CHARACTER
?
.60
CMD>
.n
 CANTON REFERENCE CODE:     2

      CANTON SPANISH TITLE
          CRUCERO DEL BELEN
CMD>
.change fill
 => PLEASE ENTER REVISED FILL CHARACTER
?
.61
CMD>
.n
 CANTON REFERENCE CODE:     3

      CANTON SPANISH TITLE
          BELLA VISTA
CMD>
.change fill
 => PLEASE ENTER REVISED FILL CHARACTER
?
.62
CMD>

.
CMD>
.b
 CANTON REFERENCE CODE:     2

      CANTON SPANISH TITLE
          CRUCERO DEL BELEN

     FILL CHARACTER:  61
CMD>
.n
 CANTON REFERENCE CODE:     3

      CANTON SPANISH TITLE
          BELLA VISTA

     FILL CHARACTER:  62
CMD>
.change name
 => ENTER TITLE TYPE(SPANISH OR ENGLISH)
.spanish
 => PLEASE ENTER REVISED SPANISH NAME
.challacollo
CMD>
```

```
.change english name
 ************************************************
 ************************************************
 ***                                          ***
 ***   E. R. R. O. R.                         ***
 ***                                          ***
 ***    THE CHANGE COMMAND WAS EITHER TYPED IN  ***
 ***    INCORRECTLY  OR IS NO LONGER IN EFFECT..***
 ***                                          ***
 ***    PLEASE CONSULT THE CHANGE SYNTAX COMMAND***
 ***    TO DETERMINE PROPER STATUS AND SYNTAX OF***
 ***    THE DESIRED COMMAND.....              ***
 ***                                          ***
 ************************************************
 ************************************************
CMD>
.change name
 => ENTER TITLE TYPE(SPANISH OR ENGLISH)
.english
 => PLEASE ENTER REVISED ENGLISH NAME
.challacollo
CMD>
.P
 PROVINCE REFERENCE CODE:    43

     SPANISH PROVINCE TITLE
          CERCADO
CMD>
.P
 DEPARTMENT REFERENCE CODE:     4

     SPANISH DEPARTMENT TITLE
          ORURO
CMD>
.P
 COUNTRY REFERENCE CODE:     1

     SPANISH COUNTRY TITLE
          BOLIVIA

     ENGLISH COUNTRY TITLE
          BOLIVIA
CMD>
.P
ELEMENT CODE:      4

     SPANISH TITLE
          LIMITES POLITICOS

     ENGLISH TITLE
          POLITICAL BOUNDARIES

     DATE LAST UPDATED
          11/ 5/81

     DATA HISTORY DOCUMENT
          NUMBER:    0 MONTH:    0 YEAR:    0

THERE ARE:   3 FILL CHARACTERS ASSIGNED


CMD>
.stop
FILE 'TROUBLE FILE A' NOT FOUND.
R; T=11.37/20.53 14:23:02

.log
CONNECT= 00:41:40 VIRTCPU= 000:12.00 TOTCPU= 000:21.98
LOGOFF AT 14:23:15 EST THURSDAY 11/05/81
```

REFERENCES

Salton, Gerard (1968), "Automatic Information Organization and Retrieval," McGraw-Hill Book Company, New York, 1968.

Swain, P.H. and S.M. Davis (1978), "Remote Sensing: The Quantitative Approach," McGraw-Hill Book Company, New York, 1978.

Thierauf, R.J. (1975), "Systems Analysis and Design of Real-Time Management Information Systems," Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1975.

Appendix A

SOME OBSERVATIONS ON INCLUDING SOCIO-ECONOMIC VARIABLES IN THE BOLIVIAN GEOGRAPHIC INFORMATION SYSTEM

by

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West Lafayette, Indiana
July 1981

TABLE OF CONTENTS

I. The Resource Concept

The resource concept is an equation which includes and centers on people. It is the human knowledge and appraisal of the phenomena which transforms it into a "resource". People are not only creators and users of resources, but they themselves are resources. The numbers of people, their abilities as indicated by their level of education, skills, ideas, etc., are important factors in any resource oriented information system.

Just as land-use, soils, climate, and landforms vary from place to place, so do peole in terms of their numbers and associated social, cultural and economic attributes. It is useful to know the average rainfall for all of Oruro, but it is most practical for planning purposes to know the spatial pattern of rainfall variation from place to place. Similarly, it would be useful to know the spatial distribution of people with certain levels of education, people who lack some of the amenities of life, and so forth. The spatial patterns of these social attributes can be effectively displayed on maps, just like the land resources have been.

II. Concept of Aggregated vs. Spatially Disaggregated Models

Aggregated models which deal with the area as a whole are necessary and useful; but planners and decision makers also need spatially disaggregated models which deal with the variation from place to place within the total area. For example it is very useful to have a cohort survival population projection for Oruro as a whole; but it is also very useful and practical to know the population projections for Oruro by Provinces and/or by Cantons, or by Language speaking groups.

Bolivia is fortunate in possessing a modern census. However, the census publications are spatially aggregated at the Department level. This means that while one can get excellent information for a Department as a whole, (as shown in the attached Indice de Cuadros for the Total Department of Oruro), it is very difficult to get information at other spatially disaggregated levels such as the Provinces or the Cantons. At the national level, the Department is a reasonable unit of analysis for summarizing the Nation's population; but for regional planning, and policy implementation, it is desirable to know the patterns within the Department.

My preliminary conclusion is that for planning purposes for the nation as a whole, the Provinces would be a more effective level of areal resolution than the Departments; and for sub-regional planning of a Department, some areal units smaller than the Provinces, would be most revealing.

III. Variables Available in Published Form by Cantons

A. SOURCE

The Bolivian Instituto Nacional de Estadistica has published the Resultados Provisionales, of the September 1976 Census. Copies of these provisional results for each of the Departments of Bolivia, except Beni and Pando, are available in the University of Wisconsin General Library. LARS, Purdue, has a copy of the Resultados Provisionales, Departamento de Oruro, Mayo 1977.

The useful aspect of these booklets is that the information is provided not only for each province within the Departments, but also for each canton within the provinces. This means that for about 90% of the developed ecumene of Bolivia, planners can do analysis at the spatial resolution level of the province, and also at the canton level. By way of illustration, this means that one can get answers not only to the question: "What percent of the population of Oruro is urban?"; but also to the question: "How does the proportion of people living in urban areas vary from place to place within Oruro?"

On the negative side, the utility of these Resultados Provisionales, is constrained by a) limitations in the number of variables included, and b) adjustments which need to be done to allow for differences in Canton boundaries and nomenclature.

B. VARIABLES IN THE RESULTADOS PROVISIONALES

1. Total Population
2. Male Population
3. Female Population
4. Urban Population
5. Urban Male Population
6. Urban Female Population
7. Total Dispersed Population
8. Dispersed Male Population
9. Dispersed Female Population

C. ALGORITHMICALLY DERIVED VARIABLES

From this limited set of population information at least four types of demographic information may be analyzed in a spatially-referenced framework. These are:

1. Population density
2. Sex ratio
3. Urbanization
4. Population potential

1. Population density. This may be defined as

$$P(J) / A(J)$$

where

P(J) = Number of people in Place (J),
A(J) = Area of Place (J)

The specific kinds of population density measures are:

a) Total population density by cantons
b) Rural population density by cantons

These can be digitally processed and displayed as maps. However, by digitally merging this data with land use or other channels in the geographic information system, other kinds of population density may be obtained and displayed on maps. Some examples are:

c) Map of agricultural density by cantons.
d) Maps of population density for different types of terrain areas, by cantons.

2. Sex ratio. Sex ratio is defined as

$$\frac{\text{Total male population}}{\text{Total female population}} \times 100$$

This is usually expressed as males per 100 females. Possible maps include:

a) Map of sex ratio of total population by cantons
b) Map of urban sex ratio by cantons
c) Map of rural sex ratio by cantons.

3. Urbanization. Because this information is spatially referenced by pointer-structure linkage to the political area channel, one can produce:

a) Map of Percent Urban by canton
b) Map of Percent Rural by canton

4. Population Potential. When phenomena are spatially referenced, they may be analyzed with reference to particular properties of place as space. For a stimulating discussion of the nature of space and place see Yi-fu Tuan (1979). Perhaps we are most familiar with linkages of some kinds of phenomena to the area-property of space, as exhibited by density measures. Nystuen (1963) has attempted to identify some fundamental spatial concepts, and came up with direction, distance, and connection or relative position.

Population potential is an example of the linkage of the size or mass of the phenomena to the distance property which is intrinsic in the notion of

spatial. This is a social analogue of the Newtonian gravity model. If all places are at the same distance from where we are, the larger places (population) will have more influence on us. If all places are the same size, then those places farther away from us will have less influence than those places nearer to us.

These two trends are combined to give us the notion of the potential at a point as an aggregate measure of the influence of all other points on that point, including the influence of the point itself. Population Potential is thus a function of size and distance and may be expressed symbolically:

$$V_i = \frac{M_1}{d_{i1}} + \frac{M_2}{d_{i2}} + \ldots + \frac{M_j}{d_{ij}} + \ldots + \frac{M_n}{d_{in}} + \frac{M_i}{d_{ii}}$$

that is: $$V_i = \sum_{j=1}^{n} \frac{M_i}{d_{ij}}$$

where: V = total potential at place i,
M = the size of another place in the bounded region, and
d = the distance separating i and j.

The symbol d_{ii} cannot be zero. Usually, half the distance between point i and its nearest neighbor is used for d_{ii}. See Abler, Adams, and Gould (1971) for a clear introductory discussion of this concept.

Other variables may be substituted for Population. For example, using retail sales per unit area as mass, and transportation cost as a measure of distance would give market potential. For the Oruro Geographic Information System, the population potential at each canton could be calculated, and a poulation potential map constructed. This would provide an index of the degree of accessibility of each canton. Furthermore, the population potential surface itself, has been found to be a correlate of many other socio-economic conditions.

D. SUMMARY LIST OF MAPS

Population Density
1. Total population density by cantons.
2. Rural population density by cantons.
3. Map of agricultural density by cantons.

Sex Ratio
4. Map of sex ratio of total population by cantons.
5. Map of urban sex ratio by cantons.
6. Map of rural sex ratio by cantons.

Urbanization
7. Map of percent urban by cantons.
8. Map of percent rural by cantons.

Population Potential

9. Map of population potential.

IV. THE FIDELITY OF CANTONS AND CANTON BOUNDARIES

A map of cantons at a scale of 1:500,000 was obtained from the Instituto Nacional de Estadistica, Bolivia. This map shows the names and boundaries of 110 cantons plus the city of Oruro, resulting in 111 areal units.

The set of cantons displayed on the INE map were then compared with the listing of cantons published in the Resultados Provisionales, 1977, by the Instituto Nacional de Estadistica. Two kinds of discrepancies were observed:

1) Places listed as "cantons" in the Provisional Census, but which do not appear on the INE map of cantons.
2) Places displayed as "cantons" on the map of cantons, but are not listed in the Provisional Census.

V. SUGGESTED LIST OF DATA ITEMS TO BE OBTAINED FROM ORIGINAL TAPES - CENSO DE POBLACION Y VIVIENDA 1976

A. DATOS GENERALES
   1. Sex
   2. Age
   3. Place of Birth
   4. Habitual Place of Residence
   5. Habitual Residence 5 Years Ago (1971)
   6. Bolivian Language Spoken

B. DATOS EDUCACIONALES
   6. Literacy (Sabe leer y escribir)
   7. Level of education (Cual es el ultimo curso aprobado y en que ciclo?)

C. DATOS ECONOMICOS
   7. Labor force status (A que dedico la mayor parte de su tiempo la semana anterior (al dia del Censo))
   8. Principal Occupation
   9. Rama de Actividad (Que produce o a que principalmente, el lugar, establecimiento a negocios, donde desempeno la ocupacion indicada?)

D. DATOS DE FECUNDIDAD
   10. Children everborn (En total cuantos hijos nacidos vivos ha tenido?)
   11. Children born alive during year preceding date of census

E. DATOS DE ESTADO CIVIL
   12. Marital Status (Cual es su estado civil actual?)

F. VIVIENDA
   13. Energia electrica
   14. Tenencia
   15. Idioma que se habla mas frecuentemente en su familia
   16. Procedencia del agua

G. UBICACION GEOGRAFICA
   17. Departamento
   18. Provincia
   19. Canton
   20. Ciudad o Localidad

The attached list of suggested data items are selections from a copy of the actual census questionnaire (also attached), from which one may algorithmically derive most of the tables listed in the attached Indice de Cuadros for the Total Department of Oruro. Because of the constraints of costs, this is only a suggested listing. One possibility is to take a systematic sample, perhaps a 25% sample stratified by cantons; so as to ensure complete representation of the geo-referencing plane for the socio-economic data, which is the Canton for the Bolivian GIS.

In addition, the cost factor may mean that only a limited number of variables can be obtained from the original census tapes. To assist the planners in deciding which variables they would like to give priority in the first phase of the project, I will attempt a brief elaboration of kinds of applications to which some of these data items may be put.

VI. DATA ITEMS IN THE BOLIVIAN CENSUS AND SOME POSSIBLE APPLICATIONS

1. Age.

The age structure of the population is a fundamental demographic variable. A great deal of technically sophisticated demographic models require it as input. For example:

a) the cohort survival method of population projection
b) life table estimations
c) census estimates of fertility, such as the fertility ratio

$$\frac{\text{children 0-4}}{\text{women in child bearing ages}}$$

the dependency ratio

$$\frac{\text{pop (0-15) + (over 65)}}{\text{pop 15-64}}$$

These census estimates of fertility and dependency can be mapped by Cantons, to reveal patterns of high, moderate and low fertility

d) mapping total population over 65, will give distribution of the elderly
e) one can also map special interest age groups, such as those of school age, and so forth.

These patterns can be correlated with other socio-economic data, and other land resource variables. Future patterns can also be projected, and impact and change analyses carried out.

2. Place of Birth

A modernizing population is very mobile both socially and spatially. Life-time migration can be compiled from place of birth data. If the original census tape data are available, then life-time migration matrices can be compiled for special groups; for cultural language groups for example.

Habitual place of residence 5 years ago, enables more recent population movements to be analyzed and displayed, and again, this can be done for special cultural groups from the original census data.

Rural-urban migration, areas which are growing in population, areas which are declining, are some of the topics which can be analyzed at a spatially disaggregated level with this kind of data. It would be of interest to do change analysis of socio-economic data to see the impact of the location of industrial activities on settlement patterns and population growth.

3. Labor force status, occupation etc., are standard census variables and their potential applications are probably more well known. The location of the trained labor force with respect to the location of new industrial and mining developments may be a topic which should be studied not only at the aggregated level but at the disaggregated sub-regional levels.

4. Datos de Fecundidad

This kind of data may seem more esoteric to the laymen, even though their inclusion in the Bolivian census is in keeping with standard international census procedures. In countries, where for a variety of reasons, accurate birth registration is not available for the entire

country, the census time is when demographers try to get a baseline measurement of the fertility patterns in the country. Children ever-born is a strong correlate of current fertility patterns, and children born alive during year preceding the census, is a good estimate of current fertility during the census year. It provides a baseline for evaluating sample surveys of fertility. However, because it is done for the whole country for every small region, one can construct maps of fertility for the entire nation. Fertility is a major determinant of population trends, and if one knows the spatial pattern of current fertility and its correlates, better regional population forecasts can be made.

5. Data on "Vivienda"

Regional variations in level of living can be derived from this kind of data. Where are the growth centers, where are the areas which are progressing slower? What are the correlates of these conditions? Maps of these items can be produced.

6. Data on Cities and Localities, provide the basis for urban studies; of settlement patterns and growth. Many developing countries are experiencing rapid urban growth. These can be mapped, and projections made.

VII. SOME EMERGING ISSUES IN ANALYZING DATA FILES OF SPATIALLY REFERENCED SOCIO-ECONOMIC PHENOMENA IN GEOGRAPHIC INFORMATION SYSTEMS

The Delineation of Socio-economic Regions

So far the observations have dealt with each data item, individually or topically. The state of the arts is such that socio-economic regions based on multiple criteria can be derived rapidly and efficiently by multivariate data reduction techniques on the computer.

The classification techniques of "unsupervised" classification is well-known in remote sensing. The same or parallel techniques are available for socio-economic phenomena, and can be used to delineate social regions which can be geo-referenced and merged with other land resource data.

The Synthesis of Social, Economic and Land Resource Information

Multivariate regionalization of physical phenomena is well established. Numerically derived social areas are also well established.

Grand composite regions of both social and physical phenomena are also possible. Some of my recent graduate students have done this for Nigeria, Uganda and Iran.

In summary, once the land resource data are entered in the data base, and social data made available, either in digitized map pattern files, or stored in tabular files linked to the canton file, a variety of topical, bivariate, and multivariable composite analyses and modeling can be performed.

INDICE DE CUADROS

TOTAL DEPARTAMENTO DE ORURO

POBLACION

VIVIENDA

MINISTERIO DE PLANEAMIENTO Y COORDINACION

REPUBLICA DE BOLIVIA

INSTITUTO NACIONAL DE ESTADISTICA

CENSO DE POBLACION Y VIVIENDA 1976

I.- UBICACION GEOGRAFICA

BOLETA Nº .....

1.- DEPARTAMENTO ____ ____
2.- PROVINCIA ____ ____
3.- CANTON ____ ____
4.- CIUDAD O LOCALIDAD ____ ____
5.- ZONA Nº ..... 6.- SECTOR Nº ..... 7.- SEGMENTO Nº .....

8.- MANZANA Nº .....
9.- DIRECCION DOMICILIARIA DE LA VIVIENDA
Calle _____ Nº .....
Piso Nº ..... Departamento Nº .....
Camino o carretera _____

VIVIENDA Nº .....
Nº DE HOGARES EN ESTA VIVIENDA .....
HOGAR Nº .....

II.- VIVIENDA

1 TIPO DE VIVIENDA

1.1 VIVIENDA PARTICULAR
- Casa independiente ☐ 11
- Departamento ☐ 12
- Habitación (es) suelta (s) en casa de vecindad ☐ 13
- Choza, pahuichi ☐ 14
- Vivienda improvisada ☐ 15
- Local no destinado a vivienda ☐ 16
- Otra _____ (Especificar) ☐ 17

1.2 VIVIENDA COLECTIVA
- Hotel, residencial ☐ 21
- Cuartel, establecimiento militar o policial ☐ 22
- Hospital, sanatorio, clínica ☐ 23
- Cárcel, establecimiento correccional ☐ 24
- Convento, institución religiosa ☐ 25
- Internado educacional ☐ 26
- Otra _____ (Especificar) ☐ 27

Para viviendas colectivas pasar a Personas

2 CONDICION DE OCUPACION
- Con ocupantes presentes ☐ 1
- Con ocupantes ausentes ☐ 2
- Desocupada ☐ 3

3 MATERIALES PREDOMINANTES EN LA VIVIENDA

3.1 TECHO
- Calamina ☐ 1
- Tejas (Cemento, arcilla, fibrocemento etc.) ☐ 2
- Losa de hormigón ☐ 3
- Paja, caña, palma ☐ 4
- Otros _____ (Especificar) ☐ 5

3.2 PAREDES EXTERIORES
- Adobe revocado ☐ 1
- Adobe sin revocar y tapial ☐ 2
- Ladrillo, bloques de cemento, etc. ☐ 3
- Piedra ☐ 4
- Madera ☐ 5
- Caña, palma, troncos ☐ 6
- Otros _____ (Especificar) ☐ 7

3.3 PISOS
- Madera ☐ 1
- Mosaico o baldosas ☐ 2
- Ladrillo ☐ 3
- Cemento ☐ 4
- Tierra ☐ 5
- Otros _____ (Especificar) ☐ 6

A PARTIR DE ESTE TEMA, LOS DATOS SE REFIEREN A CADA HOGAR DENTRO DE LA VIVIENDA.

4 DISPONIBILIDAD DE SERVICIO DE AGUA

4.1 SISTEMA DE ABASTECIMIENTO DE AGUA
- Por cañería dentro de la vivienda ☐ 1
- Por cañería fuera de la vivienda, pero dentro del edificio, lote o terreno ☐ 2
- Por cañería fuera del lote o terreno ☐ 3
- No recibe agua por cañería ☐ 4

4.2 PROCEDENCIA DEL AGUA
- Red Pública ☐ 1
- Red privada ☐ 2
- Pozo o noria ☐ 3
- Aljibe ☐ 4
- Río, lago, vertiente o acequia ☐ 5
- Carro repartidor ☐ 6
- Otra _____ (Especificar) ☐ 7

5 DISPONIBILIDAD DE SERVICIO HIGIENICO (EXCUSADO, LETRINA)
- Tiene de uso privado o exclusivo ☐ 1
- Tiene de uso común o compartido ☐ 2
- No tiene ☐ 3

6 SISTEMA DE ELIMINACION DE AGUAS SERVIDAS
- Alcantarillado público ☐ 1
- Cámara séptica ☐ 2
- Letrina o pozo ciego ☐ 3
- No tiene ☐ 4

7 DUCHA O TINA DE BAÑO
- Tiene de uso privado o exclusivo ☐ 1
- Tiene de uso común o compartido ☐ 2
- No tiene ☐ 3

8 ENERGIA ELECTRICA

Tiene electricidad? Si ☐ 1 No ☐ 2

9 NUMERO DE CUARTOS O HABITACIONES EN EL HOGAR

9.1 Cuántos cuartos o habitaciones tiene Ud. en su hogar? (No contar cuartos de baño y cocina) _____ Número

9.2 De éstos, cuántos se utilizan sólo para dormir? (dormitorios) _____ Número

10 CUARTO DE COCINA

Tiene cuarto especial para la cocina?
Si ☐ 1
No ☐ 2

11 TENENCIA
- Propia ☐ 1
- Alquilada ☐ 2
- Contrato anticrético ☐ 3
- Contrato mixto (Alquiler anticrético) ☐ 4
- Cedida por servicios ☐ 5
- Otra forma _____ (Especificar) ☐ 6

12 IDIOMA QUE SE HABLA MAS FRECUENTEMENTE EN SU FAMILIA
- Quechua ☐ 1
- Aymara ☐ 2
- Castellano ☐ 3
- Otro idioma nacional ☐ 4
- Idioma extranjero ☐ 5

RESUMEN DE POBLACION

Nº de Hombres .....
Nº de Mujeres .....
Total .....

_____
Firma del Empadronador

.....
Fecha

_____
Firma del Jefe de Sector

.....
Fecha

OBSERVACIONES

III.- POBLACION

PREGUNTAS	Nº	PRIMERA PERSONA	SEGUNDA PERSONA	TERCERA PERSONA
A .- DATOS GENERALES		PARA TODAS LAS PERSONAS CUALQUIERA SEA SU EDAD (incluidos los recien nacidos)		
Cuál es su nombre y apellido ? Anote todas las personas que pasaron la noche anterior al día del Censo en la vivienda que investiga	1	____________ Nombre y Apellido	____________ Nombre y Apellido	____________ Nombre y Apellido
Qué parentesco o relación tiene con el jefe del hogar ?	2	JEFE ☐ 1	Esposa (o) Conviviente ☐ 2 Hijo (a) o entenado ☐ 3 Yerno o nuera ☐ 4 Nieto (a) ☐ 5 Padre o suegro ☐ 6 Otro pariente ☐ 7 Empleados (cama adentro) ☐ 8 No familiar ☐ 9	Esposa (o) Conviviente ☐ 2 Hijo (a) o entenado ☐ 3 Yerno o nuera ☐ 4 Nieto (a) ☐ 5 Padre o suegro ☐ 6 Otro pariente ☐ 7 Empleados (cama adentro) ☐ 8 No familiar ☐ 9
Es hombre o mujer ?	3	Hombre ☐ 1 Mujer ☐ 2	Hombre ☐ 1 Mujer ☐ 2	Hombre ☐ 1 Mujer ☐ 2
Cuántos años cumplidos tiene ? Para personas menores de 1 año, marque 00	4	Años	Años	Años ....
Dónde nació ? Si nació en esta misma localidad, marque AQUI, si nació en otro lugar anote primero la localidad lo más concretamente posible, y luego la provincia y el departamento. Si nació fuera de Bolivia anote sólo el país	5	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________
Dónde reside habitualmente ? Si reside habitualmente en esta misma localidad, marque AQUI, si reside habitualmente en otro lugar, anote primero la localidad lo más concretamente posible, y luego la provincia y el departamento. Si reside habitualmente fuera de Bolivia, anote sólo el país	6	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________
Dónde residía habitualmente hace 5 años ? (1971) Si residía habitualmente en esta misma localidad, marque AQUI, si residía habitualmente en otro lugar, anote primero la localidad lo más concretamente posible y luego la provincia y el departamento. Si residía habitualmente fuera de Bolivia, anote sólo el país	7	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________	Aquí ☐ Otra localidad ________ Provincia ________ Depto. u otro país ________
Qué idiomas bolivianos sabe hablar ? " SABE " significa poder comunicar sus ideas en este idioma, no basta entender. Si habla más de un idioma marque una de las casillas 5 a 9	8	Aún no habla o Ninguno ☐ 0 Castellano ☐ 1 Aymara ☐ 2 Quechua ☐ 3 Otro ☐ 4 Castellano-Aymara ☐ 5 Castellano-Quechua ☐ 6 Castellano con otro ☐ 7 Aymara-Quechua ☐ 8 Castellano-Aymara - Quechua ☐ 9	Aún no habla o Ninguno ☐ 0 Castellano ☐ 1 Aymara ☐ 2 Quechua ☐ 3 Otro ☐ 4 Castellano-Aymara ☐ 5 Castellano-Quechua ☐ 6 Castellano con otro ☐ 7 Aymara-Quechua ☐ 8 Castellano-Aymara - Quechua ☐ 9	Aún no habla o Ninguno ☐ 0 Castellano ☐ 1 Aymara ☐ 2 Quechua ☐ 3 Otro ☐ 4 Castellano-Aymara ☐ 5 Castellano-Quechua ☐ 6 Castellano con otro ☐ 7 Aymara-Quechua ☐ 8 Castellano-Aymara - Quechua ☐ 9
B.- DATOS EDUCACIONALES		- SOLO PARA PERSONAS DE 5 AÑOS Y MAS DE EDAD		
Sabe leer y escribir ? Si sólo sabe leer o firmar, marque NO	9	Si ☐ 1 No ☐ 2	Si ☐ 1 No ☐ 2	Si ☐ 1 No ☐ 2
Asiste a la escuela u otro centro educativo ?	10	Si ☐ 1 No ☐ 2	Si ☐ 1 No ☐ 2	Si ☐ 1 No ☐ 2
Cuál es el último curso aprobado y en que ciclo ? Anote en la línea correspondiente el último curso aprobado. Para el que contesta según el sistema antiguo, anote primaria o secundaria y escriba en la línea correspondiente el último curso aprobado	11	Ninguno 00 ☐ Sólo alfabetización 01 ☐ Básico 1 ..... Intermedio 2 ..... Medio 3 ..... Primaria 4 ..... Secundaria 5 ..... Normal 6 ..... Universitario 7 ..... Otro ____ 8 ..... Especificar	Ninguno 00 ☐ Sólo alfabetización 01 ☐ Básico 1 ..... Intermedio 2 ..... Medio 3 ..... Primaria 4 ..... Secundaria 5 ..... Normal 6 ..... Universitario 7 ..... Otro ____ 8 ..... Especificar	Ninguno 00 ☐ Sólo alfabetización 01 ☐ Básico 1 ..... Intermedio 2 ..... Medio 3 ..... Primaria 4 ..... Secundaria 5 ..... Normal 6 ..... Universitario 7 ..... Otro ____ 8 ..... Especificar
C.- DATOS ECONOMICOS		- SOLO PARA PERSONAS DE 7 AÑOS Y MAS DE EDAD		
A qué dedicó la mayor parte de su tiempo la semana anterior (al día del Censo) ? Solamente si usted marca las casillas 1, 2 o 3, debe hacer las preguntas 13, 14 y 15. Si marca una de las casillas restantes, pase directamente a la pregunta 16.	12	Trabajó .... ☐ 1 No trabajó, pero tenía trabajo? (vacaciones, enfermedad, etc.) .... ☐ 2 Desocupado? .... ☐ 3 Buscó trabajo por primera vez? .... ☐ 4 Sólo labores de casa? .... ☐ 5 Sólo Estudiante? .... ☐ 6 Jubilado y/o rentista? .... ☐ 7 Otros? Especificar .... ☐ 8	Trabajó .... ☐ 1 No trabajó, pero tenía trabajo? (vacaciones, enfermedad, etc.) .... ☐ 2 Desocupado? .... ☐ 3 Buscó trabajo por primera vez? .... ☐ 4 Sólo labores de casa? .... ☐ 5 Sólo Estudiante? .... ☐ 6 Jubilado y/o rentista? .... ☐ 7 Otros? Especificar .... ☐ 8	Trabajó .... ☐ 1 No trabajó, pero tenía trabajo? (vacaciones, enfermedad, etc.) .... ☐ 2 Desocupado? .... ☐ 3 Buscó trabajo por primera vez? .... ☐ 4 Sólo labores de casa? .... ☐ 5 Sólo Estudiante? .... ☐ 6 Jubilado y/o rentista? .... ☐ 7 Otros? Especificar .... ☐ 8
Cuál fue la principal ocupación o trabajo que realizó durante la semana anterior o su último trabajo si estuvo desocupado? Anote por ejemplo. Agricultor, zafrero, comerciante minorista, perforista de minas, sastre, médico, empleada doméstica, etc.	13	____________ Ocupación	____________ Ocupación	____________ Ocupación
Qué produce o a qué se dedica principalmente el lugar, establecimiento o negocio donde desempeñó la ocupación indicada? Ej. Especifique: Explotación minera de estaño, cultivos agrícolas, lechería, fabricación de zapatos, reparación de radios, transporte automotor de pasajeros, comercio al por menor, función pública, etc.	14	____________ Rama de actividad	____________ Rama de actividad	____________ Rama de actividad
Cuál fue la categoría o posición en la ocupación que indica ?	15	Obrero? (Peón, capataz, jornalero) .... ☐ 1 Empleado? .... ☐ 2 Trabajador familiar no remunerado? .... ☐ 3 Trabajador por cuenta propia? (No tiene empleados u obreros pagados) .... ☐ 4 Patrón o empleador? (Tiene empleados u obreros pagados) .... ☐ 5	Obrero? (Peón, capataz, jornalero) .... ☐ 1 Empleado? .... ☐ 2 Trabajador familiar no remunerado? .... ☐ 3 Trabajador por cuenta propia? (No tiene empleados u obreros pagados) .... ☐ 4 Patrón o empleador? (Tiene empleados u obreros pagados) .... ☐ 5	Obrero? (Peón, capataz, jornalero) .... ☐ 1 Empleado? .... ☐ 2 Trabajador familiar no remunerado? .... ☐ 3 Trabajador por cuenta propia? (No tiene empleados u obreros pagados) .... ☐ 4 Patrón o empleador? (Tiene empleados u obreros pagados) .... ☐ 5
D.- DATOS DE FECUNDIDAD		- SOLO PARA MUJERES DE 12 AÑOS Y MAS DE EDAD		
a) En total cuántos hijos nacidos vivos ha tenido ? Aunque después hayan muerto. b) De ellos cuántos están actualmente vivos ? c) Qué mes y año nació su último hijo nacido vivo ? Aunque después éste haya muerto	16	Nº........ Ninguno ☐ 00 Ignora ☐ 99 Nº........ Ninguno ☐ 00 Ignora ☐ 99 .... mes y año de nacimiento	Nº........ Ninguno ☐ 00 Ignora ☐ 99 Nº........ Ninguno ☐ 00 Ignora ☐ 99 .... mes y año de nacimiento	Nº........ Ninguno ☐ 00 Ignora ☐ 99 Nº........ Ninguno ☐ 00 Ignora ☐ 99 .... mes y año de nacimiento
E.- DATOS DE ESTADO CIVIL		SOLO PARA PERSONAS DE 12 AÑOS Y MAS DE EDAD		
Cuál es su estado civil actual ?	17	Soltero (a) .... ☐ 1 Casado (a) o Conviviente .... ☐ 2 Viudo (a) .... ☐ 3 Divorciado (a) o Separado (a) .... ☐ 4	Soltero (a) .... ☐ 1 Casado (a) o Conviviente .... ☐ 2 Viudo (a) .... ☐ 3 Divorciado (a) o Separado (a) .... ☐ 4	Soltero (a) .... ☐ 1 Casado (a) o Conviviente .... ☐ 2 Viudo (a) .... ☐ 3 Divorciado (a) o Separado (a) .... ☐ 4

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