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TOPOG: A Computerized Worldwide Terrain Elevation Data Base Generation and Retrieval System

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

Figure | Page

LIST OF TABLES

TOPOG

A Computerized Worldwide Terrain Elevation Data Base Generation and Retrieval System

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S.J. Paulson*

TOPOG is a computerized worldwide terrain elevation data base generation and retrieval system. It consists of software to generate TOPOG tapes from Defense Mapping Agency (DMA) standard terrain elevation data tapes, to create auxiliary random-access disk files containing TOPOG data for a user-defined area, and to extract path profiles from the auxiliary disk files. The data base and software are designed for a CDC 6000[1] series computer with a NOS or NOS/BE operating system.

Key words: computer software; data base; terrain elevation data; TOPOG

1. INTRODUCTION

1.1 Background

The behavior of radio communication systems is often influenced in an important way by surrounding topography (Bullington, 1947; Rice, et al., 1967). To better predict the performance of such systems, a variety of computerized techniques has been developed that attempts to account for the effects of irregular terrain (Longley and Rice, 1968; Ott, et al, 1979). Digital terrain elevation data bases, stored on magnetic tapes or disks and accessed by relevant applications software, have become an essential element in utilizing these procedures. The following examples illustrate this point.

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[1]Certain commercial equipment, and materials are identified in this paper to specify adequately the software requirements. In no case does such identification imply recommendation or endorsement by the authors, the National Telecommunications and Information Administration, or the U.S. Department of Commerce.

In the first example, the objective is to locate a transmitter at one of several candidate sites so as to maximize line-of-sight coverage over a specified area. To assist in this process, one may employ a computer routine which accesses a digital topographic data base and generates a map overlay depicting terrain not visible from a specified point. If the objective is to minimize interference with other systems, one may employ the same procedure so as to minimize line-of-sight coverage over a specified area.

Another example of a process requiring a digital terrain elevation data base is a computer implementation of a communication system performance model developed at the Institute for Telecommunication Sciences of the U.S. Department of Commerce (Jennings and Paulson, 1977). Output from this program (CSPM) includes a contour plot of a quality-of-service parameter covering a specified area surrounding a transmitter. Input to the model contains information derived from terrain profiles along propagation paths between the transmitter and a large number of potential receiving sites. These profiles are automatically generated by a computer program that accesses a digital topographic data base.

Since the early 1970's, the Institute for Telecommunication Sciences (ITS) has utilized one or another of several versions of a topographic data base principally covering the continental United States (CONUS) and portions of western Europe. These data bases were supplied by the Electromagnetic Compatilbility Analysis Center (ECAC) and adapted by George Hufford for ITS needs (ECAC, 1977). The ECAC terrain elevation data was in turn generated by the Defense Mapping Agency (DMA) from 1:250,000-scale topographic maps. A brief discussion of the DMA digitizing procedure is included in Section 1.4.1 of this report. A detailed description of the ITS-modified data base is contained in the report by Jennings and Paulson (1977).

The elevation sample points of the ECAC data base constitute a latitude/longitude grid with a 30-second interval. On the earth's surface, this corresponds to a sample point interval of approximately one kilometer. If one applies the sampling theorem of signal theory to this situation, it follows that the 30-second data base will not represent terrain irregularities whose horizontal dimensions are less than approximately two kilometers (Tobler, 1969). In other words, a 30-second grid interval acts like a low-pass filter in smoothing the terrain.

Depending on the nature of the particular application and the character of the topography, a 30-second grid interval may suffice. In other situations, a smaller sampling interval may be needed to adequately represent the terrain. Late in 1976, under the sponsorship of the U.S. Army Communications-Electronic Engineering Installation Agency at Fort Huachuca, Arizona, ITS began work on a project whose primary aim was to design a global digital terrain elevation data base providing significantly greater detail than that available with the 30-second data base currently in use. The TOPOG data base and related software described in this report are an outgrowth of that project.

1.2 Alternative Data Base Designs

An ideal topographic data base occupies minimal storage space while enabling users to rapidly and accurately determine the elevation at any specified location within the covered area. In the real world, however, the incorporation of any one of these attributes in a particular data base design is usually achieved only at the expense of some other desirable feature. For example, given the irregular nature of most terrain surfaces, increased accuracy in determining elevations of arbitrary points requires a "denser" set of sample points to facilitate the necessary interpolation procedures. This, of course, results in a more voluminous data base. Numerous other instances of a similar nature could be cited, leading one to the conclusion that some sort of tradeoff between ideal data base attributes is unavoidable.

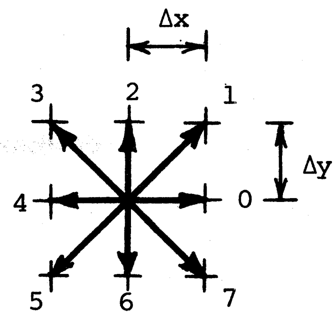
A guiding principle in the ITS approach to designing a global topographic data base was to place a high premium on those features that facilitate the effective use of the data base in typical telecommunications applications (e.g. in generating terrain profiles along radio propagation paths). With this principle in mind, several alternative designs were considered for a terrain elevation data base. These are briefly discussed in Sections 1.2.1 through 1.2.3.

1.2.1 Elevation Contour Data

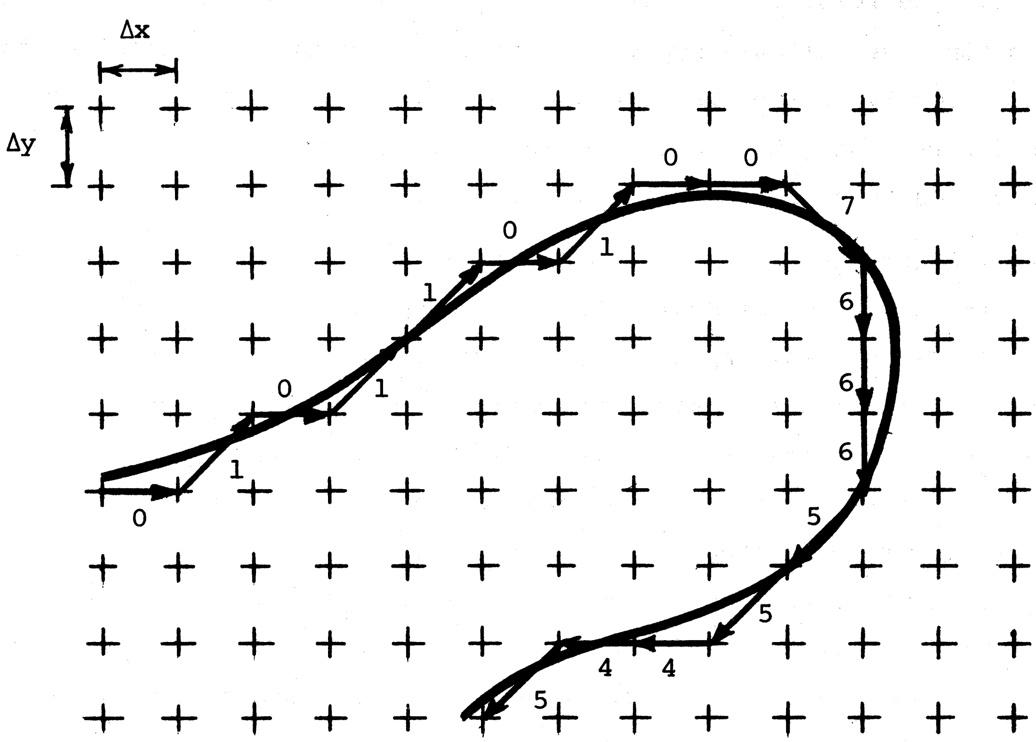
The essential idea in this design is that of representing, in digital form, the location of particular elevation contours. The basic approach is to approximate a curved contour line on a specified map by a sequence of straight line segments. The line segment approximation may be implemented in any of several ways. The least sophisticated of these simply records the end-point coordinates (in some suitable system) of the approximating variable-length segments. A closely related procedure is to regard each segment end-point as the origin for recording the next end-point; this results in a reduction of storage requirements by a factor of at least two.

A more elegant approach is to approximate a contour segment by a sequence of representative vectors belonging to a specified set, such as that illustrated in Figure 1-1. As usually implemented, a logical record corresponds to a particular contour segment. It contains the contour elevation, the coordinates of the inital point of the segment, and a string of digits identifying the successive representative vectors that approximate the contour. The record ends when the contour closes or a specified maximum number of vectors have been used. A file usually corresponds to some particular map area with defined boundaries and prescribed projection and scale. This scheme, called chain encoding, is a very compact way of recording elevation data. Note that each representative vector is specified by three binary bits. By restricting the representative vectors to those numbered 0, 2, 4, 6 in Figure 1-1, each vector may be specified by only two binary bits, and a further reduction in data volume is achieved. By choosing Δx and Δy sufficiently small, contours may be approximated to any desired precision. Accuracy in estimating elevations at arbitrarily specified locations can be improved by decreasing the vertical interval between successive contour lines. Note that these strategies aimed at increased accuracy also increase the volume of data.

The contour approach permits a very compact means of representing terrain elevation data. However, this compactness is achieved in a very costly way in



(a) Representative vector set.



(b) Approximation of contour segment by sequence of representative vectors.

Figure 1-1. Digital representation of elevation contours.

applications that require elevation values at specified locations. To estimate such a value requires a time-consuming search to locate the records corresponding to a pair of contour segments lying to either side of the given point. Further search is required to locate, within those records, the line segments or vectors nearest the point so that effective interpolation procedures may be employed. The upshot is that applications in which the elevation of many thousands of points must be determined require computer run times that range from many tens to several hundreds of hours. On the basis of these considerations, the contour approach to data base design was rejected.

1.2.2 Gridded Elevation Data

The essential idea in this design is to record elevations at a systematic two-dimensional grid of sample locations spanning the desired geographical area. This approach may be implemented using a latitude/longitude grid, a rectangular grid on a particular map with defined boundaries and prescribed projection and scale, or some other grid, such as one based on the Universal Transverse Mercator (UTM) grid. In every case, the geographical location corresponding to a particular elevation value actually stored in a data record is implied by the position of that value in a string of values contained in the record.

The main virtue of gridded elevation data lies in the ease with which it can be utilized to determine the elevations at arbitrarily specified locations. The usual procedure is to extract from the data base the elevations of the grid points forming the corners of a rectangular "cell" containing the given location, then apply an interpolation procedure to estimate the elevation at that location. Because of the systematic manner of data storage, locations containing the needed grid point elevations can be calculated, thus eliminating the need for any search procedures.

Increased accuracy in elevation estimation is attained by decreasing the interval between adjacent grid points. The principal cost of this consists of increased data storage requirements. Note that the volume of data is inversely proportional to the square of the basic grid interval.

If a grid interval is chosen to adequately sample the most irregular terrain, then many of the grid point elevations in areas of rather flat terrain may be redundant. This is especially true when the recorded elevation values have limited precision, such as that corresponding to a contour interval for a topographic map. Under these circumstances, a string of elevation values consists of a sequence of sub-strings in which the recorded elevation values are equal. This situation is illustrated in Figure 1-2. Considerable effort was devoted to designing a gridded topographic data base in which the recorded data consist of lengths and elevations of such sub-strings. It was eventually recognized that storage savings were insignificant, whereas elevation determination times were increased twenty- to fifty-fold. This approach was then abandoned.

1.2.3 Terrain Surface Representation by Mathematical Functions

The essential idea in this approach is to approximate the terrain surface over a suitably restricted area by some appropriate mathematical function. In general, the chosen function contains a number of adjustable parameters or coefficients that allows the function to be fitted to the actual terrain surface in some optimum manner. Given the urgency of the need for an improved "working" topographic data base, it did not seem that techniques for functional representation of terrain surface are sufficiently developed to merit serious consideration as a design alternative for such a data base. Examples of possible techniques are discussed in a series of reports issued by the U.S. Army Engineer Topographic Laboratories (e.g., Jancaitis, 1978; Jancaitis and Magee, 1978).

1.3 Overview of the TOPOG System

The name TOPOG is used to refer to the ITS-designed global terrain elevation data base, and to the associated software for generating and retrieving its constituent data. Some major features of the TOPOG system are indicated schematically in Figure 1-3. This section presents a brief overview of that system and serves as a guide to the more detailed discussions contained in the remainder of the report.

In telecommunication applications, the principal uses of topographic data bases involve determining elevations at specified locations. An example is the generation of terrain profiles from elevation values at a set of equally

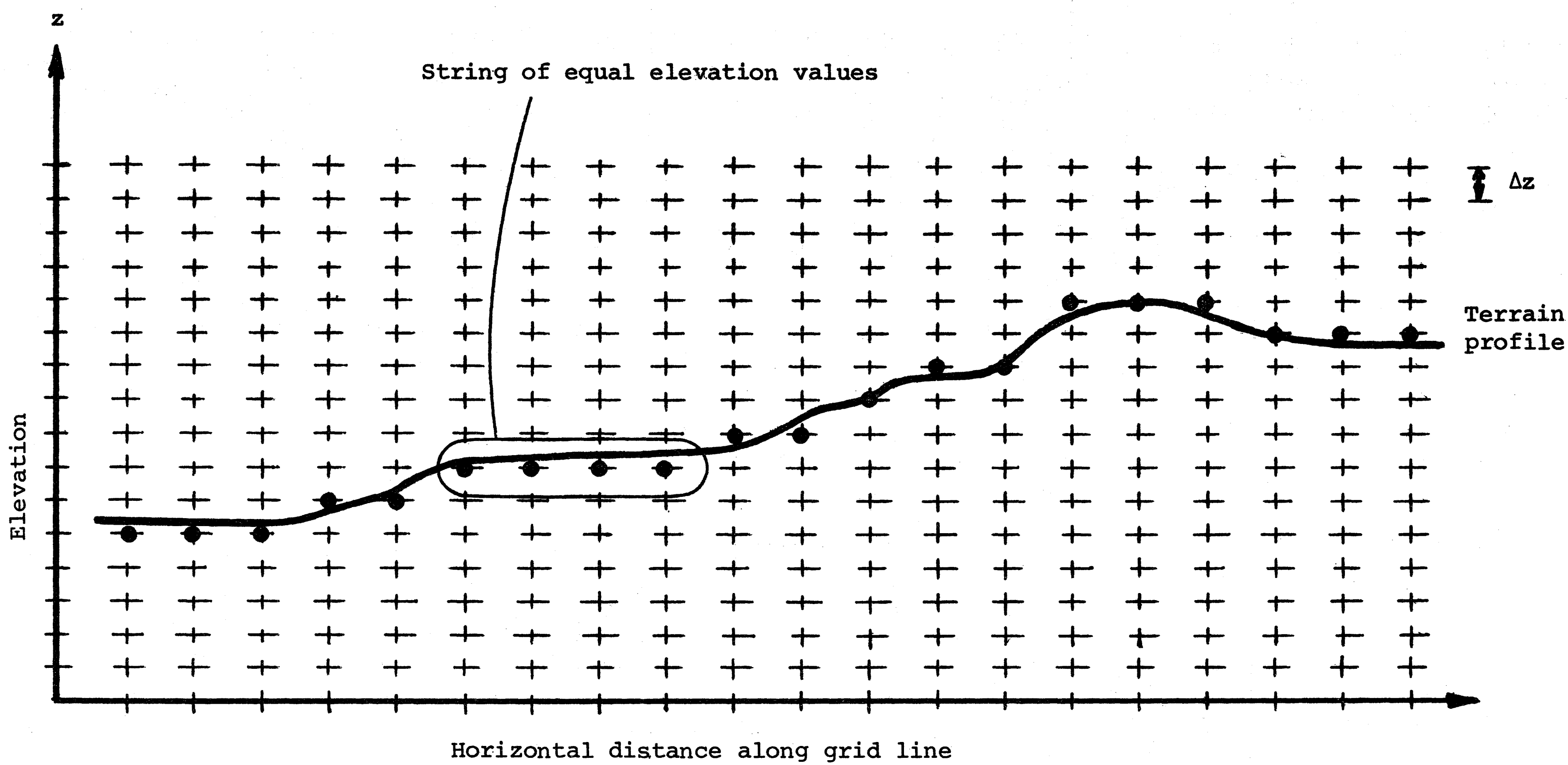


Figure 1-2. Approximation of terrain height by grid point elevation values with resolution Δz.

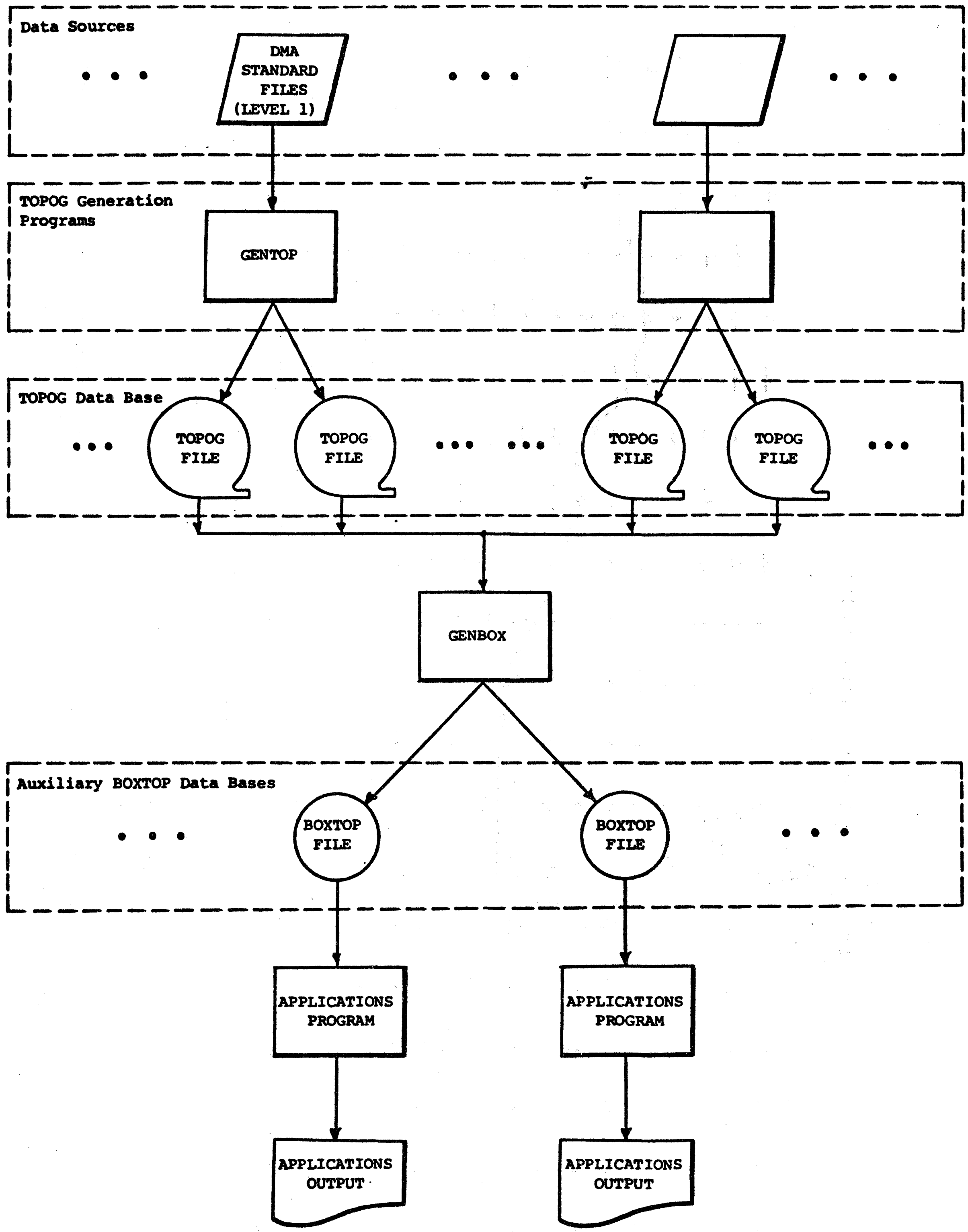


Figure 1-3. Major features of a TOPOG system.

spaced points along transmitter/receiver paths. To maximize the rate at which location-specific elevations may be evaluated, the TOPOG data base is designed to consist of gridded data. The TOPOG sample points are the nodes of a global latitude/longitude grid whose fundamental interval is three seconds. This corresponds to a sample point separation of roughly 100 meters on the surface of the earth. The latitude/longitude grid eliminates the need to deal with map projections and scales when estimating the elevations of points whose geographical coordinates are prescribed. The sample point separation, which is one-tenth of that for the ECAC/ITS data base currently in use, should provide a sufficiently detailed representation of terrain surfaces for essentially all telecommunication applications. At the same time, the total potential data volume of 1000-2000 tapes is not unmanageably large. Details of the TOPOG data grid are described in Section 2.2.1.

A TOPOG data base consists of a set of terrain elevation files and a TOPOG directory file. Each TOPOG file is stored on a single magnetic tape containing only that file. A TOPOG terrain elevation file includes a sequence of directory records followed by a sequence of terrain elevation data records. Each data record contains terrain elevation values for a particular sequence of TOPOG grid points. The TOPOG files and their constituent records form a data structure hierarchy based on a systematic partitioning of the earth's surface into a corresponding hierarchy of geographical elements. Together, the TOPOG geographical elements and corresponding data structures form a global scheme that facilitates the systematic and efficient storage and retrieval of terrain elevation values. TOPOG geographical elements and data structures are described in detail in Section 2.

It is anticipated that terrain elevation files in a TOPOG data base will be derived from a variety of data sources. Some significant potential sources of TOPOG data are described in Section 1.4. In general, elevation sample point configurations and data formats will vary from one data source to another, whereas those for the TOPOG data base are standardized and independent of data source. As a consequence, any computer program that generates TOPOG terrain elevation files from a given data source must include data extraction and processing software designed specifically for that particular source. If elevation sample point locations for the source data do not coincide with those of TOPOG, the program must contain appropriate interpolation procedures.

One of the more extensive sources of digital terrain elevation data, and certainly one of the easiest to convert to the TOPOG format, consists of the DMA Level 1 Standard Files. A brief description of these files is included in Section 1.4. A computer program (GENTOP) for generating TOPOG files from DMA Level 1 files has been developed and is described in Section 5. Detailed information on file characteristics and record formats is contained in the Appendix. At the present time, GENTOP is the only existing computer program for generating TOPOG data.

While effective as a global archive for storing topographic data, TOPOG terrain elevation files are often not suitable as a "working" data base for particular applications. This is especially true when the required data records are not located in a single TOPOG file (i.e. tape). An example of the problems that arise is given in Section 3.1. To deal with this situation, the TOPOG system allows the data base user to define an area of interest by specifying a pair of boundary parallels and a pair of boundary meridians. This information is supplied to a computer program (GENBOX) which then extracts the relevant records from the TOPOG data base and places them in a word-addressable file (BOXTOP) stored on magnetic disk. To facilitate data retrieval from BOXTOP, GENBOX also creates a set of directory records and writes these in that file. The BOXTOP file is then used as the "working" data base for the particular application. A detailed description of BOXTOP files is contained in Section 3, and the program GENBOX is discussed in Section 6.

For their operation, both GENTOP and GENBOX require information from the directory file that contains data pertaining to the terrain elevation files contained in a particular TOPOG data base. The contents of a TOPOG data base at a given installation will vary with time as terrain elevation files are added and possibly deleted. It is anticipated that a data base will include both files generated by the installation and files obtained from other installations. To be effective, the directory file for a particular data base must accurately reflect the contents of that data base. A computer program (FIXDRY) has been developed to maintain the directory file for any given TOPOG data base. This program is described in Section 4.

To provide an example of application software, the program CSPM (Jennings and Paulson, 1977) has been modified to utilize a BOXTOP file as its topographic data input. These modifications are briefly described in Section 7.

The TOPOG data base and related software described in this report are designed for a CDC 6000 series computer with a NOS or NOS/BE operating system.

1.4 Sources of Digitized Topographic Data

As previously mentioned, it is anticipated that TOPOG data will be derived from a variety of sources. This section contains brief descriptions of several major existing and/or potential sources of digitized terrain elevation data that might be utilized in generating TOPOG files.

1.4.1 DMA Digital Terrain Tapes

Digital terrain tapes were generated by the Defense Mapping Agency (DMA) from 1:250,000-scale maps as a part of that agency's program to produce raised-relief maps. In the 1960's, DMA developed the Digital Graphics Recorder (DGR) consisting of an automatic digitizing table and a computer system, for recording a grid of terrain elevations from contour traces on a map. A 0.01-inch grid covers the area to be digitized. As a stylus is traced along a contour, the DGR records the coordinates of the grid points that approximate the contour, as indicated in Figure 1-4. After all contours have been digitized, elevations of remaining grid points (not representing contour lines) are estimated by interpolation procedures. The resulting data were organized into 1° x 1° blocks and stored on magnetic tapes.

Originally, DMA digital terrain tapes were employed to control machine carving of plaster forms used to mold raised-relief maps. Current versions of these tapes are distributed to the public by the National Cartographic Information Center (NCIC) of the United States Geological Survey (USGS). DMA digital terrain tapes available from NCIC cover all of the continental United States (CONUS). A description of relevant data formats is contained in a users guide (NCIC, 1979).

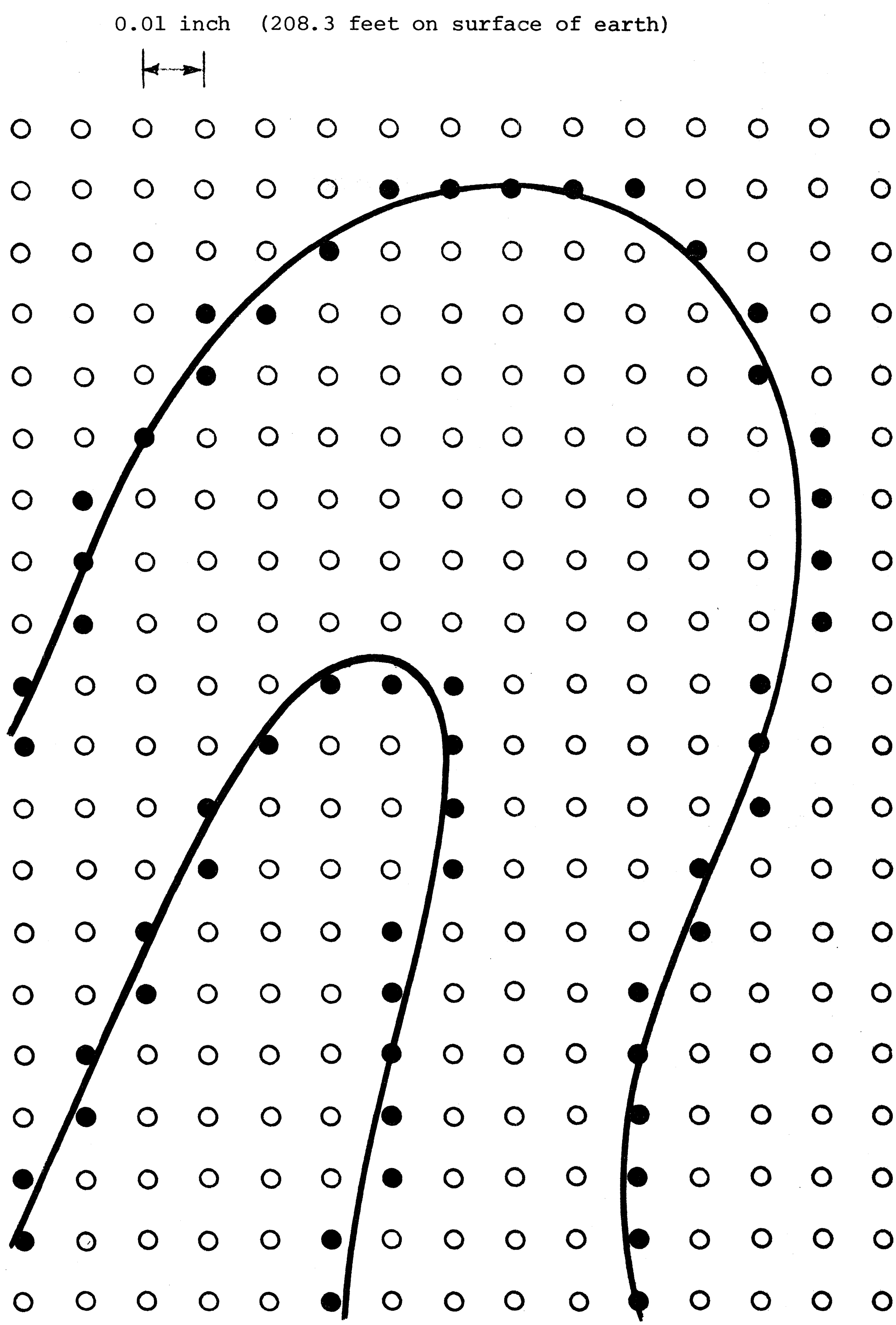


Figure 1-4. Approximation of contours on DMA data grid.

The data contained in DMA digital terrain tapes are subject to all of the shortcomings inherent in the 1:250,000-scale maps from which they were derived, as well as additional errors introduced in the digitizing process. For example, those maps do not necessarily conform with National Map Accuracy Standards in either horizontal or vertical control. More serious, however, are errors resulting from interpolating grid point elevations between contour lines. Such errors can be especially severe in areas of low relief, where contour lines are widely separated. All too frequently, these elevation errors are nearly as large as the map contour interval (100 or 200 feet).

1.4.2 DMA Level 1 Standard Files

DMA Level 1 Standard Files are essentially modified versions of the digital terrain tapes described in the preceding section. Instead of a rectangular grid on a planar map, the sample points for Level 1 files form a latitude/longitude grid whose basic interval is three seconds. At higher latitudes, the longitude grid interval is increased in a series of steps to compensate for meridional convergence. The various grid intervals are detailed in Table 1-1.

Table 1-1. Longitude Grid Intervals for DMA Level 1 Standard Files

$\lvert\phi\rvert$	$\Delta\lambda_G$
0°-50°	3"
50°-70°	6"
70°-75°	9"
75°-80°	12"
80°-90°	18"

In the case of CONUS, the Level 1 Standard Files are being generated by DMA by reprocessing data contained in digital terrain tapes. Like those tapes, Level 1 Files for CONUS and Alaska are distributed for public use by NCIC. Files for approximately half of CONUS are currently available, while the remaining files are scheduled to be completed within the next few years. The structure of DMA Level 1 Files is described in detail in the Appendix to this report.

Data in DMA Level 1 Files are subject to the errors described in Section 1.4.1 for digital terrain tapes. From the standpoint of TOPOG, the chief virtue of Level 1 files is the relative ease with which the data may be utilized to generate TOPOG files. In most cases, the grid points for the two data bases coincide; at worst, only a simple linear interpolation along grid parallels is necessary.

1.4.3 USGS Digital Elevation Models

Digital elevation models (DEM's) are produced by the USGS by digitizing existing 1:24,000-scale maps and directly from stereo pairs of high altitude photographs. The sample points form a UTM-based grid whose basic interval is 30 meters. Data formats and indexes to completed DEM's can be obtained from the NCIC, who distribute these files to the public.

Digital elevation models form a promising source of high quality terrain elevation data to replace TOPOG records derived from DMA level 1 Standard Files. However, the necessary software, which must include interpolation procedures to estimate elevations at TOPOG grid points, has not been developed.

2. ORGANIZATION AND STRUCTURE OF THE TOPOG DATA BASE

2.1 Overview

As stated previously, the TOPOG data base consists of a set of terrain elevation files and a TOPOG directory file. The TOPOG files and records constitute a hierarchy of data structures based on a systematic partitioning of the earth's surface into a corresponding hierarchy of geographical elements. A brief introductory description of TOPOG geographical elements and their relation to TOPOG data structures is included in this section, while detailed discussions of these topics are contained in Sections 2.2 and 2.3, respectively.

The basic scheme of the TOPOG geographical hierarchy is indicated in Figure 2-1, which illustrates elements at three key levels. The surface of the earth is partitioned by certain TOPOG grid lines into a set of 3060 TOPOG regions. Several of these are shown as the largest elements in Figure 2-1, where their boundaries are indicated by heavy lines. Their importance derives from the fact that the geographical counterpart of a terrain elevation file, called a TOPOG tape area, consists of a single region or a west-to-east sequence of two to five adjacent regions.

Each TOPOG region is divided into 15 TOPOG districts, and each TOPOG district is divided into 64 TOPOG blocks, as shown in Figure 2-1. Blocks are key elements in the system because they are the geographical counterparts of terrain elevation data records, called block data records.

TOPOG districts are the geographical counterparts of block directory records, which may be described briefly as follows. Each block in a TOPOG tape area is assigned a numerical block category code. A positive code implies the block is represented in the file by a block data record, and serves as a pointer to that record. A zero code implies the block is all ocean, so all its points are at zero elevation, and a negative code means that the file contains no elevation information for that block. A block directory record for a particular district contains the block category codes for all blocks in that district, arranged according to a prescribed block sequence. All block directory records for a given tape area are then written in a prescribed order following a preface record in the corresponding terrain elevation file.

The TOPOG directory file contains a region directory that serves, at the top of the hierarchy, a function analogous to that of block directory records. Each TOPOG region is assigned a numerical region category code. A positive code implies the region is "covered" by a terrain elevation file in the TOPOG data base, and serves as a pointer to that file. A zero code implies the region is all ocean, so all its points are at zero elevation, and

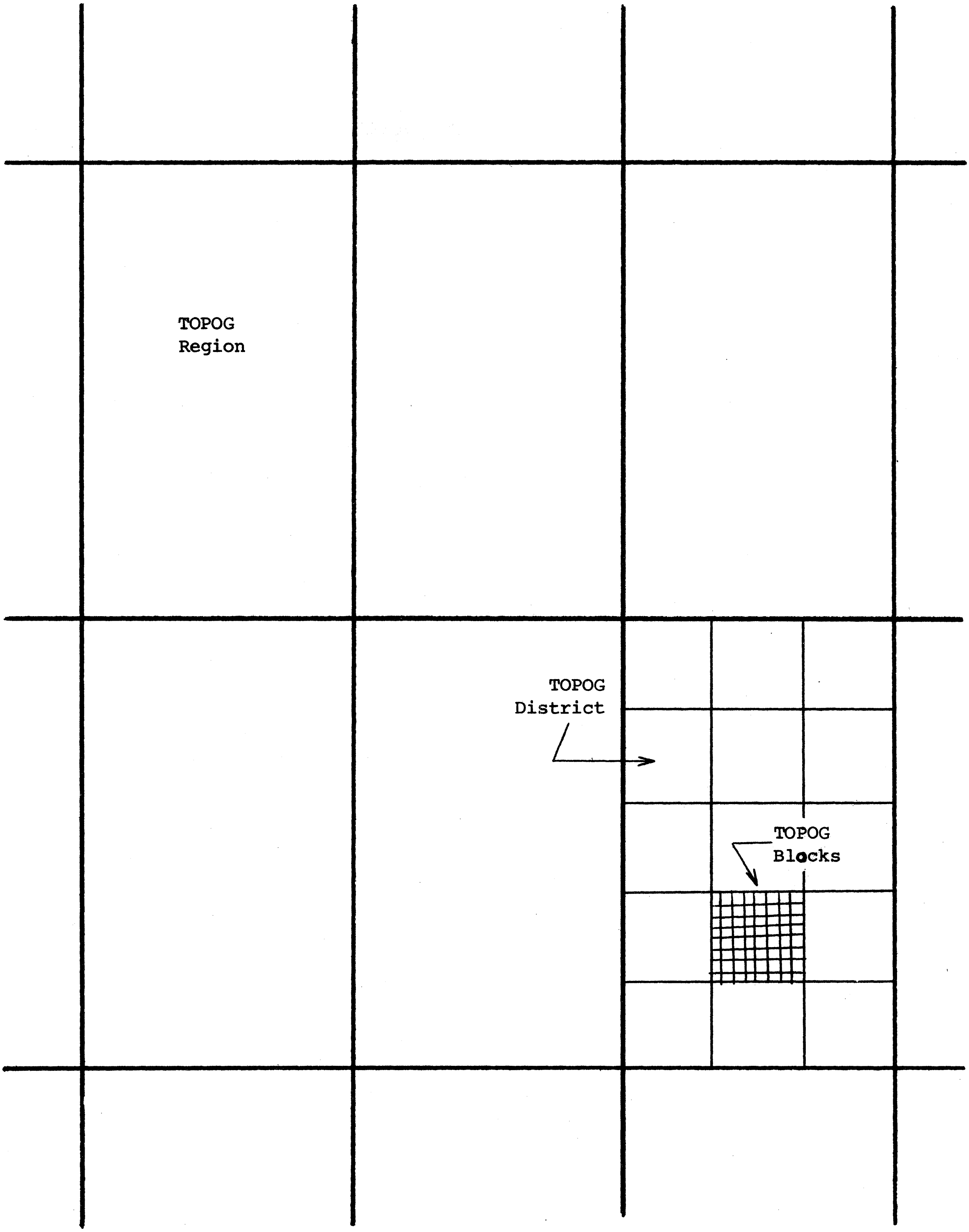


Figure 2-1. Key geographical elements of the TOPOG system.

a negative code means that no elevation information for that region is contained in the data base. The region directory contains the region category codes of all TOPOG regions, arranged according to a prescribed region sequence.

2.2 TOPOG Geographical Elements

The earth's surface, as stated previously, is systematically partitioned into a hierarchy of geographical elements that underlie the organization of the TOPOG data base and facilitate storage and retrieval of terrain elevation values. In this section, each geographical element in that hierarchy is defined and described in detail. Because all such elements are bounded by TOPOG grid lines, we start our discussion with a description of the TOPOG data grid.

2.2.1 The TOPOG Data Grid

Terrain elevation data points of the TOPOG system are located at the intersection points of a global network of grid lines on the World Geodetic System (WGS) reference spheroid. These grid lines consist of a set of parallels and a set of meridians and segments of meridians.

TOPOG grid parallels include the equator and are uniformly spaced in latitude, the angular interval $\Delta\phi_G$ between adjacent grid parallels being 3 seconds. On the surface of the earth, this separation corresponds to a linear distance of about 93 meters; an idea of the distribution of data points on maps of various scales can be obtained from the information in Table 2-1. The north and south geographic poles may be regarded as "degenerate" or "singular" cases of grid parallels.

Table 2-1. Approximate Linear Distances Between Adjacent TOPOG Grid Parallels on Maps of Selected Scales

Map Scale	Linear Separation (mm)
1: 25,000	3.71
1: 50,000	1.85
1:100,000	0.93
1:250,000	0.37
1:500,000	0.19

TOPOG grid meridians include both the prime (Greenwich) meridian and the 180th meridian. At any fixed latitude, the angular interval $\Delta\lambda_G$ between adjacent grid meridians is a constant; however, the value of this constant depends on latitude, increasing poleward in a stepwise manner in order to compensate somewhat crudely for meridional convergence. The particular values of $\Delta\lambda_G$ used in the TOPOG system are listed in Table 2-2, along with corresponding linear distances on the earth's surface. Since DMA "Standard Files" constitute a prime source of TOPOG elevation data, the TOPOG latitude intervals and $\Delta\lambda_G$ values have been chosen to coincide either with those of DMA, or to have a simple relation to them.

Table 2-2. Values of $\Delta\lambda_G$ and Corresponding Approximate Linear Distances on the Surface of the Earth

Latitude Interval	$\Delta\lambda_G$ (seconds)	Linear Distance (meters)
$(0^\circ, \pm 50^\circ)$	3	60-93
$(\pm 50^\circ, \pm 70^\circ)$	6	63-119
$(\pm 70^\circ, \pm 80^\circ)$	12	64-127
$(\pm 80^\circ, \pm 90^\circ)$	24	0-129

The total number of distinct points in the TOPOG data grid is slightly greater than 66×10^9; the exact number is 66,096,324,002. The TOPOG data base is organized in such fashion that the elevation at substantially more than half of these points can be inferred to be zero (i.e., mean sea level) without actually storing elevation values for the individual grid points.

2.2.2 TOPOG Regions

TOPOG regions are defined in two steps. In the first of these, the reference spheroid is divided by TOPOG grid parallels into 36 TOPOG zones, each spanning 5 degrees of latitude. Zones are indexed sequentially northward, with zone 1 extending from 90°S (i.e., the south pole) to 85°S. We use the following notation, where $I_Z = 1, 2, \ldots, 36$:

$$\phi_Z^S(I_Z) = \text{south boundary latitude of zone } I_Z, \tag{2.2.2-1}$$

and

$$\phi_Z^N(I_Z) = \text{north boundary latitude of zone } I_Z \tag{2.2.2-2}$$

Zones do not correspond to any TOPOG data structure, but serve as a conceptual and computational convenience. Note from Table 2-2 that the longitude grid interval $\Delta\lambda_G$ is a constant everywhere within a given zone, jumps in the value of $\Delta\lambda_G$ occurring only at zone boundaries.

In the second step of the definition, each TOPOG zone is divided into TOPOG regions by a set of grid meridians equally spaced in longitude. Boundary meridians of TOPOG regions are completely characterized by the following pair of conditions: (i) in each zone, the 180th meridian is a region boundary meridian, and (ii) the longitude dimension $\Delta\lambda_R(I_Z)$ of each TOPOG region in zone I_Z is 3600 x $\Delta\lambda_G(I_Z)$, where $\Delta\lambda_G(I_Z)$ is the constant angular interval between adjacent grid meridians in that zone.

The latitude dimension $\Delta\phi_R$ of a region is always 5°, whereas the longitude dimension $\Delta\lambda_R$ varies with the latitude of the region. Values of $\Delta\lambda_R$ are listed in Table 2-3 for the various TOPOG latitude intervals. Note that within any such interval, $\Delta\lambda_R$ expressed in degrees is numerically equal to $\Delta\lambda_G$ expressed in seconds. In middle latitudes (50°S<ϕ<50°N), a TOPOG region covers a 5° x 3° portion of the earth's surface.

Table 2-3. Longitude Dimensions of TOPOG Geographical Elements

Latitude Interval (degrees)	$\Delta\lambda_R$ (degrees)	$\Delta\lambda_D$ (degrees)	$\Delta\lambda_B$	$\Delta\lambda_G$ (seconds)
(0, $\pm$50)	3	1	7 1/2' = 1/8°	3
($\pm$50, $\pm$70)	6	2	15' = 1/4°	6
($\pm$70, $\pm$80)	12	4	30' = 1/2°	12
($\pm$80, $\pm$90)	24	8	60' = 1°	24

Within each zone, TOPOG regions are indexed sequentially eastward from the 180th meridian. A particular region may then be identified by specifying the index I_Z of the zone containing it, and the local index I_R^C of the region within that zone. To facilitate data storage and retrieval, it is advantageous to arrange the 3060 TOPOG regions in the following sequence, where each region is denoted by the index pair (I_Z, I_R^C):

(1,1),(1,2),...,(1,15),(2,1),(2,2),...,(36,1),(36,2),...,(36,15)

A region may then be identified by its global region index I_R, a single positive integer denoting the position of the region in the sequence above. Both schemes for indexing regions are shown in Figure 2-2 for the vicinity of the south pole. For region I_R^C in zone I_Z, we have the relation

$$I_R = I_R^C + \sum_{J=1}^{I_Z-1} 360/\Delta\lambda_R(J) \qquad (2.2.2\text{-}3)$$

where $\Delta\lambda_R(J)$ is expressed in degrees, and the summation is neglected when $I_Z=1$. Note that $360/\Delta\lambda_R(J)$ is the number of regions in zone J.

For region I_R, we use the following notation for region boundary coordinates:

$$\phi_R^S(I_R) = \text{south boundary latitude of region } I_R, \qquad (2.2.2\text{-}4)$$

$$\phi_R^N(I_R) = \text{north boundary latitude of region } I_R, \qquad (2.2.2\text{-}5)$$

$$\lambda_R^W(I_R) = \text{west boundary longitude of region } I_R, \qquad (2.2.2\text{-}6)$$

$$\lambda_R^E(I_R) = \text{east boundary longitude of region } I_R. \qquad (2.2.2\text{-}7)$$

The size of TOPOG regions has been chosen to satisfy several convenient criteria. If each terrain elevation file is to be stored on a separate magnetic tape, and if a region is typically the geographical counterpart of a terrain elevation file, then a TOPOG region should be defined so that the data corresponding to it will fit (with essentially zero probability of overflow) on one 2400-foot reel of magnetic tape recorded at 1600 bits per inch (bpi). At the same time, we wish to avoid (again, in the typical case) seriously under-utilizing the tape's storage capacity. To avoid complications arising from there being more than one $\Delta\lambda_G$ value within a region, any particular region must be entirely contained in one of the TOPOG latitude intervals listed in Table 2-2. The choices for $\Delta\phi_R$ then reduce to 5° or 10°. If we now impose the convenient condition that a region's longitude dimension $\Delta\lambda_R$ (in degrees) be an integer divisor of 360 for all latitudes, the storage criteria mentioned above lead at once to the TOPOG definition.

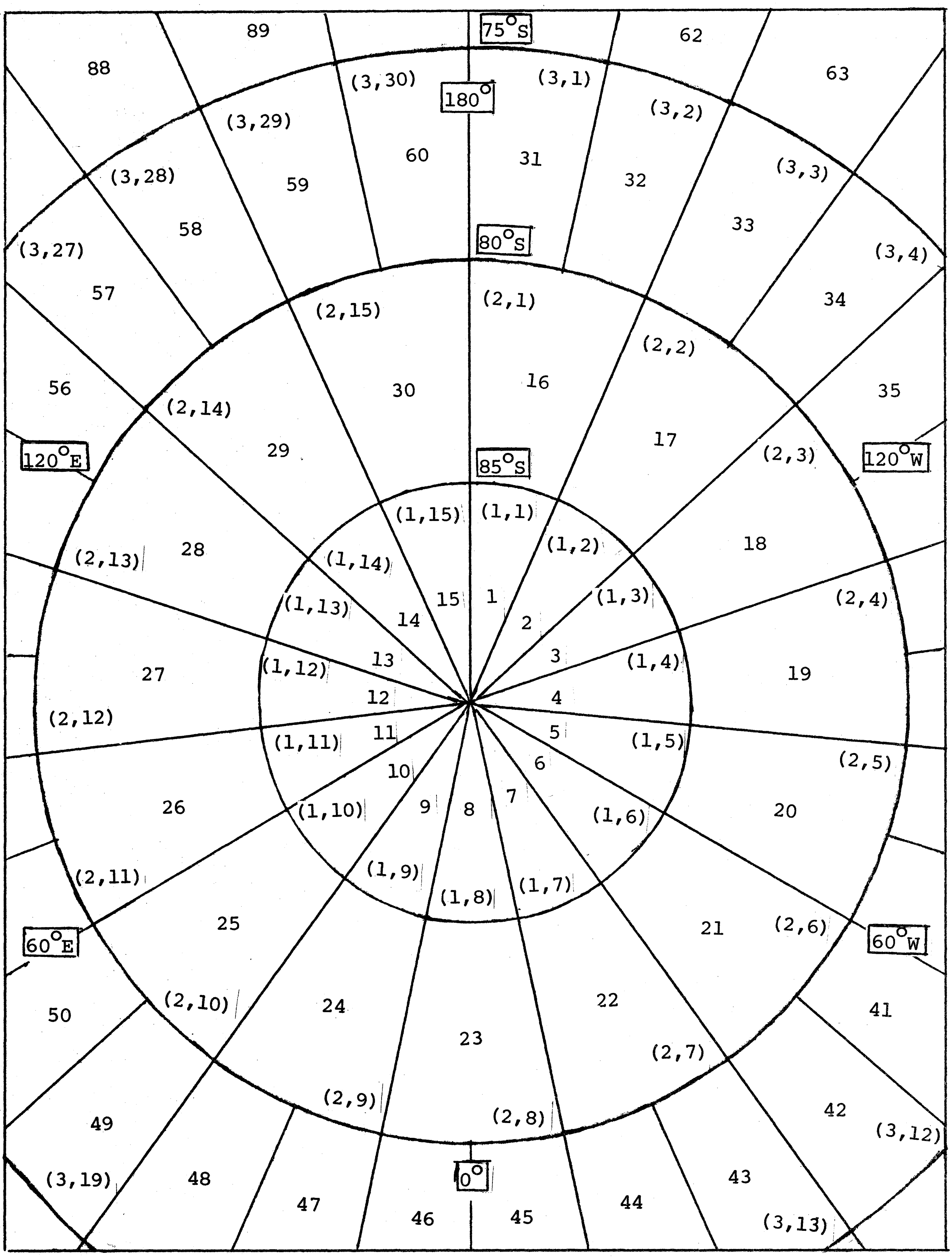


Figure 2-2. Indexing scheme for TOPOG regions.

2.2.3 TOPOG Tape Areas

As stated in Section 2.1, TOPOG terrain elevation files are maintained on magnetic tape, exactly one file being stored on a given tape. The geographical counterpart of a terrain elevation data file is called a TOPOG tape area, and consists of a single region (the typical case) or a west-to-east sequence of 2-5 adjacent regions (if sufficient ocean is included). Multi-region tape areas are subject to the restrictions that (i) they must not straddle the 180th meridian, and (ii) they must not include more 1100 TOPOG blocks that are categorized as "standard" or "missing" (these concepts are defined in Section 2.3.4).

The first restriction is included to simplify the TOPOG data storage/retrieval system. The second restriction ensures that all of the data for the tape area will fit on a single 2400-foot magnetic tape recorded at 1600 bpi. At the same time, it prevents one from defining multi-region tape areas by virtue of including territory with missing elevation data. The limit of five adjacent regions in a TOPOG tape area is somewhat arbitrary; it is motivated by the need to bound reasonably the maximum size of certain arrays that are stored by programs that generate terrain elevation files.

Among geographical elements in the TOPOG hierarchy, tape areas are peculiar in that they are not always uniquely defined by the TOPOG data storage/retrieval system. In a sequence of adjacent regions including land and sea, one may have the option of defining these as single-region tape areas, or of combining regions in a variety of ways to form one or more multi-region tape areas.

A TOPOG tape area is fully determined by specifying the global index of the first (i.e., westernmost) region in the tape area and the number N_R of regions it contains. Each tape area may also be identified by a tape area name, a string of not more than 20 characters. Tape area names are user-defined inputs to program (e.g., GENTOP) that generate terrain elevation files. Normally, they identify some prominent city or natural feature located in the tape area. If not defined by input, tape area names are left blank by default. Tape area names are not used in any essential way by the software that generates or reads the corresponding files; they are included for the benefit of human users of the TOPOG data base.

Notation for tape area boundary coordinates is analogous to that for regions. For a given tape area, we write

ϕ_T^S = south boundary latitude of tape area, (2.2.3-1)

ϕ_T^N = north boundary latitude of tape area, (2.2.3-2)

λ_T^W = west boundary longitude of tape area, (2.2.3-3)

λ_T^E = east boundary longitude of tape area. (2.2.3-4)

The longitude dimension $\Delta\lambda_T$ of a particular tape area is then

$$\Delta\lambda_T = \lambda_T^E - \lambda_T^W = N_R \times \Delta\lambda_R \tag{2.2.3-5}$$

where N_R is the number of constituent regions and $\Delta\lambda_R$ is the longitude dimension of one of those regions.

2.2.4 TOPOG Districts

Each TOPOG region is divided into 15 TOPOG districts as indicated in Figure 2-1. The latitude dimension $\Delta\phi_D$ of a district is always $\Delta\phi_R/5=1°$, whereas the longitude dimension $\Delta\lambda_D$ depends on the latitude of the district. Values of $\Delta\lambda_D$ are listed in Table 2-3 for the various TOPOG latitude intervals; within any given interval,

$$\Delta\lambda_D = \Delta\lambda_R/3 = 1200 \times \Delta\lambda_G \tag{2.2.4-1}$$

In middle latitudes ($50°S<\phi<50°N$), note that a TOPOG district encompasses a 1° x 1° portion of the earth's surface. The total number of districts is 15 x 3060 = 45,900.

In the TOPOG data storage/retrieval system, districts are indexed only within the TOPOG tape area that contains them. A dual indexing scheme, somewhat analogous to the one that has been described for regions, is used to identify districts within a TOPOG tape area; its features are illustrated in Figure 2-3. The districts within a tape area are regarded as comprising an array of 5 rows and $N_D^C = 3N_R$ columns, where N_R is the number of TOPOG regions in the tape area. A particular district may then be identified by specifying

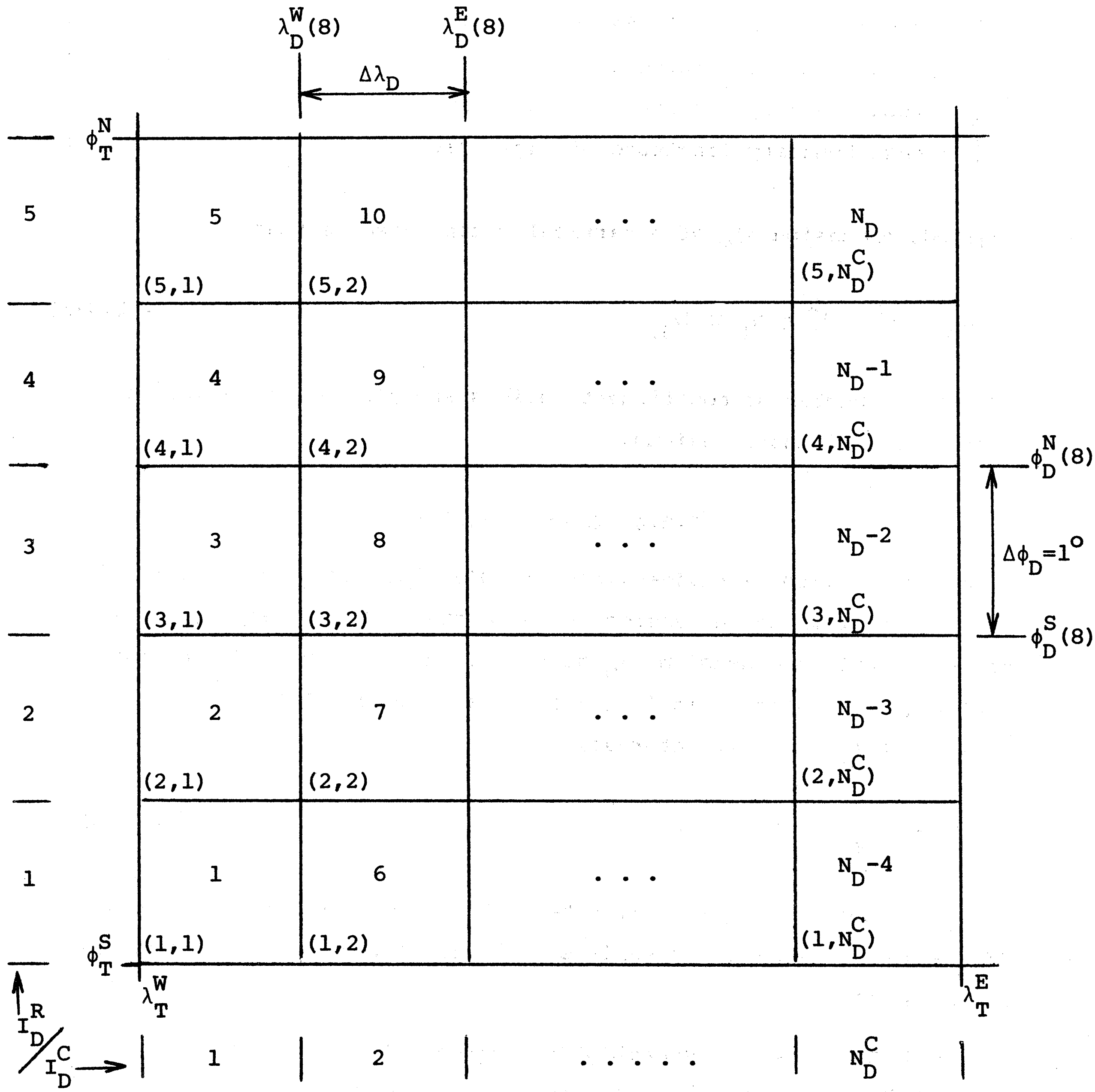


Figure 2-3. TOPOG districts within a TOPOG tape area.

its <u>district row index</u> I_D^R and <u>district column index</u> I_D^C. A district is also identified by a single index, the district index I_D, where

$$I_D = 5 \times (I_D^C - 1) + I_D^R \qquad (2.2.4\text{-}2)$$

District indexes are indicated in Figure 2-3 by the numbers written inside the district boundaries. Given the value of I_D for some district, the value of the column index I_D^C for that district is given by

$$I_D^C = [(I_D - 1)/5] + 1 \qquad (2.2.4\text{-}3)$$

where [x] means "the greatest integer not exceeding x". Once the column index I_D^C is known, one can obtain the row index I_D^R by solving (2.2.4-2) for that index. Note that I_D ranges up to $N_D = 15 \times N_R$.

Notation for district boundary coordinates is analogous to that for regions. For district I_D in a given TOPOG tape area, we write

$$\phi_D^S(I_D) = \text{south boundary latitude of district } I_D, \qquad (2.2.4\text{-}4)$$
$$\phi_D^N(I_D) = \text{north boundary latitude of district } I_D, \qquad (2.2.4\text{-}5)$$
$$\lambda_D^W(I_D) = \text{west boundary longitude of district } I_D, \qquad (2.2.4\text{-}6)$$
$$\lambda_D^E(I_D) = \text{east boundary longitude of district } I_D. \qquad (2.2.4\text{-}7)$$

2.2.5 TOPOG Blocks

Each TOPOG district is divided into 64 TOPOG <u>blocks</u> as indicated in Figures 2-1 and 2-4. The latitude dimension $\Delta\phi_B$ of a block is always $\Delta\phi_D/8$ = 1/8° = 7.5', while the longitude dimension $\Delta\lambda_B$ depends in the usual way on the latitude. Values of $\Delta\lambda_B$ for the various TOPOG latitude intervals are listed in Table 2-3; within any given latitude interval,

$$\Delta\lambda_B = \Delta\lambda_D/8 = 150 \times \Delta\lambda_G \qquad (2.2.5\text{-}1)$$

In middle latitudes (50°S < ϕ < 50°N), note that a TOPOG block is equivalent to a standard 7-1/2 minute quadrangle. The total number of TOPOG blocks is 64 x 15 x 3060 = 2,937,600.

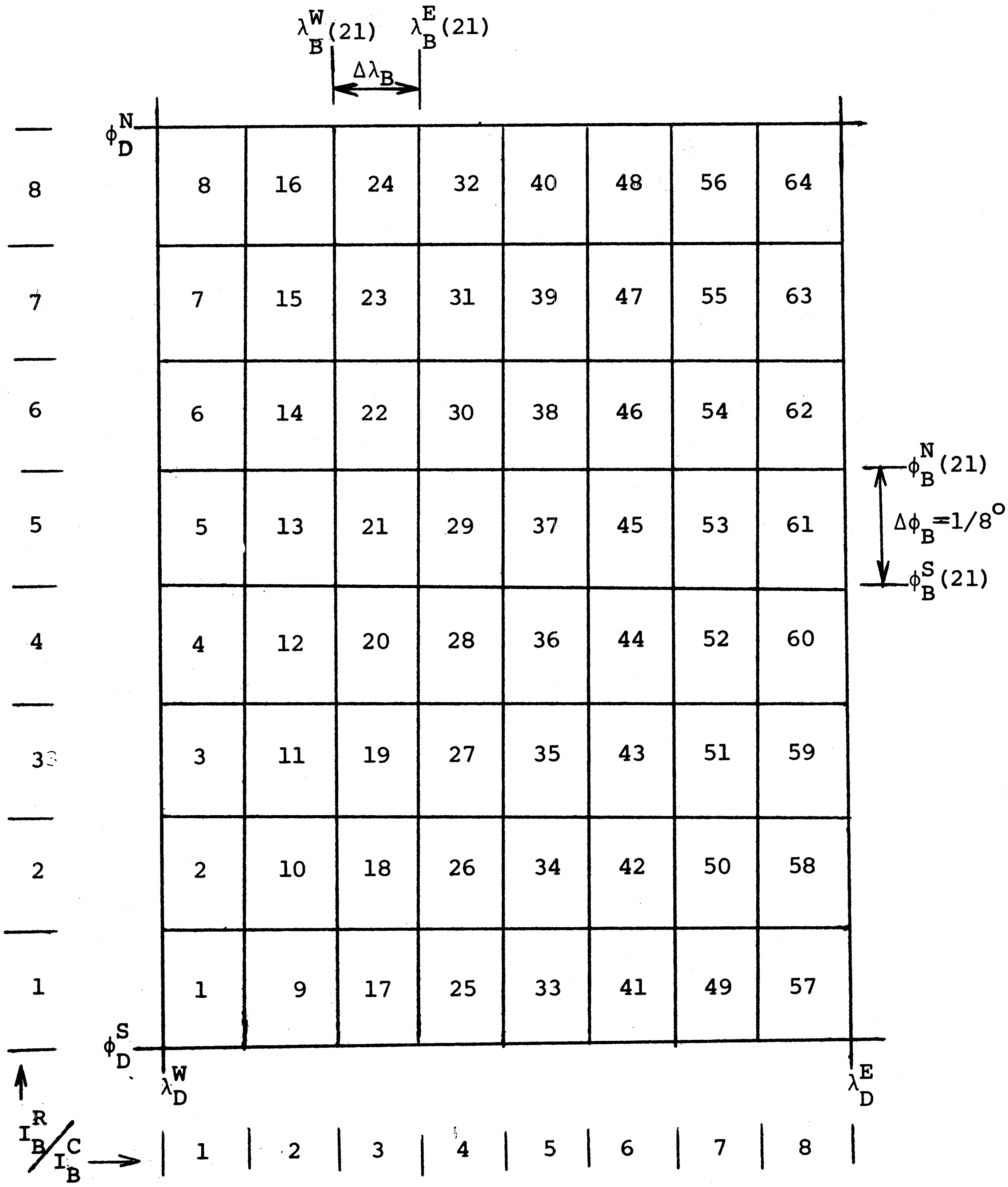


Figure 2-4. TOPOG blocks within a TOPOG district.

For data storage and retrieval, TOPOG blocks are indexed within the TOPOG district that contains them. The indexing scheme is illustrated in Figure 2-4 and is analogous to that used for districts within a TOPOG tape area. The blocks within a district comprise an array of 8 rows and 8 columns, so a particular block may be identified by specifying its <u>block row index</u> I_B^R and its <u>block column index</u> I_B^C. A block is also identified by its <u>block index</u> I_B, where

$$I_B = 8 \times (I_B^C - 1) + I_B^R. \qquad (2.2.5\text{-}2)$$

Block indexes are indicated in Figure 2-4 by the numbers written inside the block boundaries. Given the value of I_B for a particular block, the value of the column index I_B^C for that block is given by

$$I_B^C = \left[(I_B - 1)/8\right] + 1 \qquad (2.2.5\text{-}3)$$

where, as before, [x] denotes the greatest integer not exceeding x. Once the column index I_B^C is known, one can then obtain the row index I_B^R by solving (2.2.5-2) for that quantity.

Notation for block boundary coordinates is analogous to that for regions and districts. For a given block I_B in a TOPOG district, we write

$$\phi_B^S(I_B) = \text{south boundary latitude of block } I_B, \qquad (2.2.5\text{-}4)$$
$$\phi_B^N(I_B) = \text{north boundary latitude of block } I_B, \qquad (2.2.5\text{-}5)$$
$$\lambda_B^W(I_B) = \text{west boundary longitude of block } I_B, \qquad (2.2.5\text{-}6)$$
$$\lambda_B^E(I_B) = \text{east boundary longitude of block } I_B. \qquad (2.2.5\text{-}7)$$

TOPOG blocks are key geographical elements in that the counterpart of a block in the TOPOG data structures is a <u>block data record</u>. The structure of these records is described in Section 2.3.4.

The TOPOG grid points in a TOPOG block are indicated in Figure 2-5. Also shown is the within-the-block indexing scheme used by the TOPOG data storage/retrieval system to identify these points. The grid points within a TOPOG block form an array of 151 rows and 151 columns, so an individual point

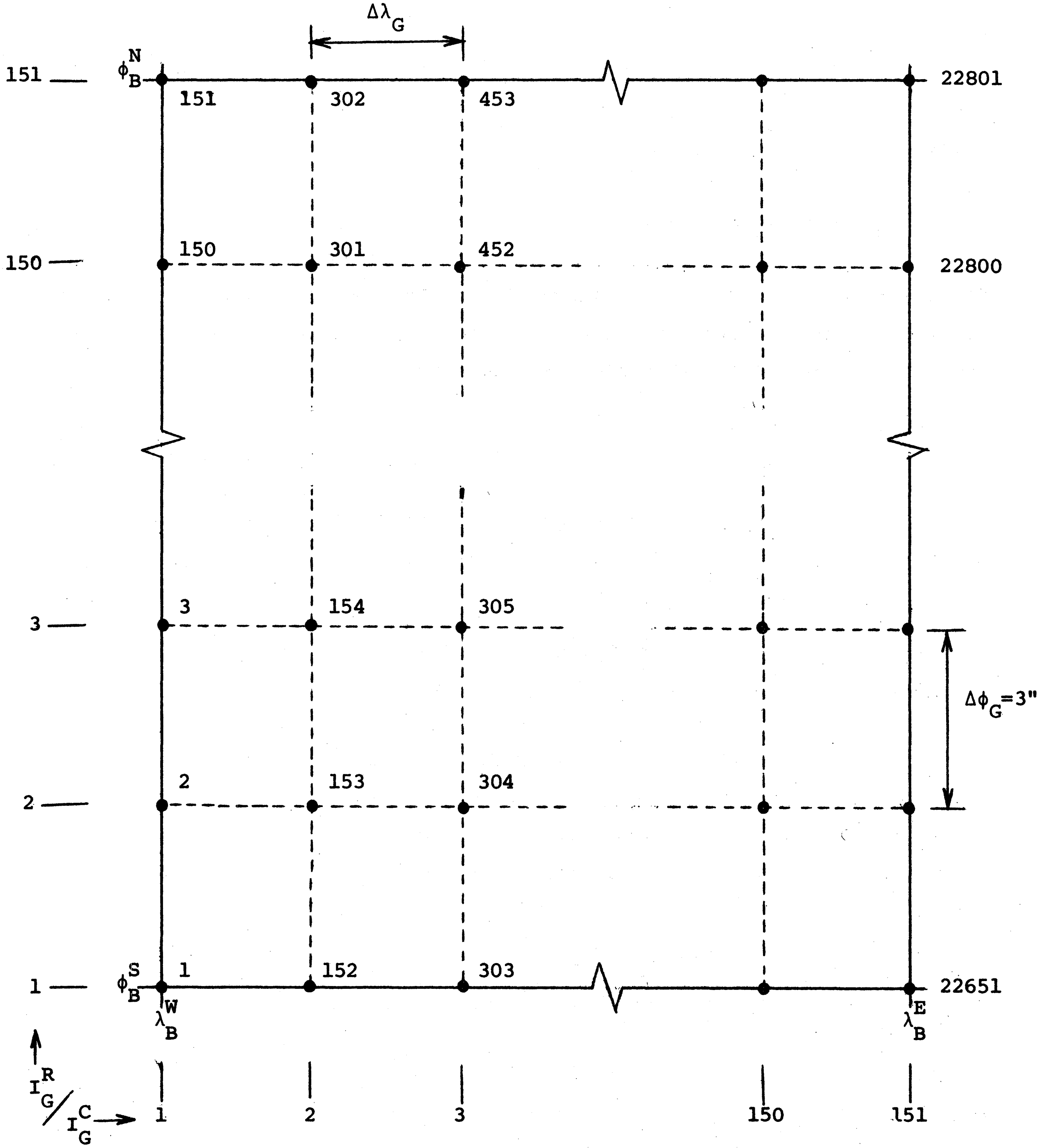


Figure 2-5. TOPOG grid points in a TOPOG block.

may be identified by specifying its grid row index I_G^R and grid column index I_G^C. A grid point is also identified by its grid point index I_G, where

$$I_G = 151 \times (I_G^C - 1) + I_G^R \qquad (2.2.5\text{-}8)$$

Given the value of I_G for a particular point, the value of its column index I_G^C is given by

$$I_G^C - [(I_G - 1)/151] + 1 \qquad (2.2.5\text{-}9)$$

where [x] denotes (as usual) the largest integer not exceeding x. Once the column index I_G^C is known, the row index I_G^R is obtained by solving (2.2.5-8) for that quantity.

2.2.6 TOPOG Cells

A TOPOG cell consists of the area bounded by a pair of adjacent TOPOG grid parallels and a pair of adjacent grid meridians. As shown in Figure 2-6, the corners of a cell consist of TOPOG grid points. Cells are the smallest elements of area in the TOPOG geographical hierarchy.

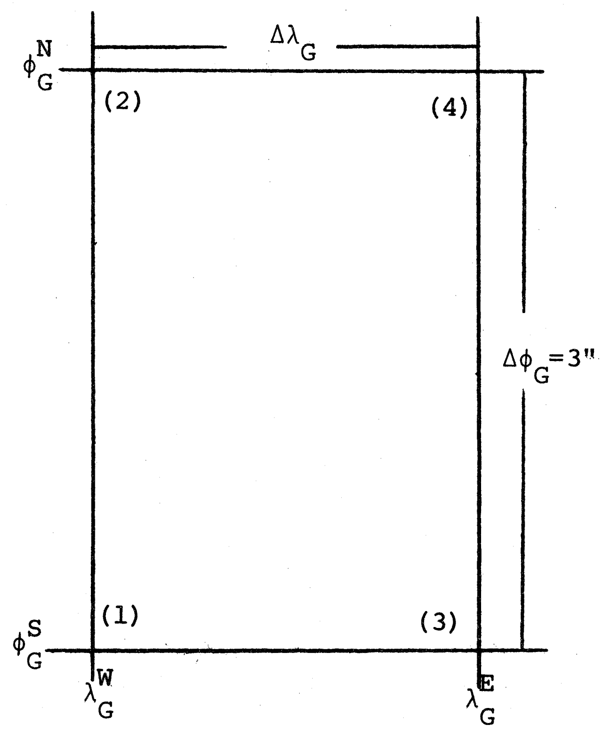


Figure 2-6. A TOPOG cell.

Each TOPOG block contains 150 x 150 = 22,500 cells, so the total number of cells is 3060 x 15 x 64 x 22500 = 66,096,000,000. Cells are not indexed in the TOPOG data storage/retrieval system, but for purposes of discussion they can be conveniently identified by the grid point index of their southwest corner. The notation for cell boundary coordinates is akin to that used for larger TOPOG elements; for a particular cell, we write

$$\phi_G^S = \text{south boundary latitude of cell,} \qquad (2.2.6\text{-}1)$$

$$\phi_G^N = \text{north boundary latitude of cell,} \qquad (2.2.6\text{-}2)$$

$$\lambda_G^W = \text{west boundary longitude of cell,} \qquad (2.2.6\text{-}3)$$

$$\lambda_G^E = \text{east boundary longitude of cell.} \qquad (2.2.6\text{-}4)$$

Cells are used in estimating the elevation $Z(\phi,\lambda)$ of an arbitrarily specified point (ϕ,λ). The grid point elevations at the corners of the cell containing (ϕ,λ) are indicated as shown in Figure 2-6 and extracted from the TOPOG data base. These are then used in the standard four-point bilinear interpolation formula to estimate $Z(\phi,\lambda)$. Section 2.4 contains a concise description of the TOPOG procedure for determining $Z(\phi,\lambda)$ when the latitude ϕ and longitude λ of the point are given.

2.3 TOPOG Data Structures

The TOPOG data base consists of a set of terrain elevation files and a TOPOG directory file which contains a directory to the terrain elevation files. All TOPOG files are stored on magnetic tape, exactly one file per tape. This section contains a detailed description of the various files and records that constitute the TOPOG data base.

2.3.1 TOPOG Terrain Elevation Files

A TOPOG terrain elevation file contains terrain elevation data corresponding to or "covering" a TOPOG tape area, which consists of a single TOPOG region or, if sufficient ocean is included, a west-to-east sequence of 2-5 such regions (tape areas are fully described in Section 2.3.5.1). Using CDC Record Manager routines, each file is written on a separate magnetic tape as a sequential file of W-type logical records that are internally blocked (this format is most suitable for use on CDC machines).

The structure of a terrain elevation file is shown in Figure 2-7. It contains a file preface record, a sequence of block directory records (one such record for each TOPOG district in the tape area), and a sequence of block data records. The numbers at the bottom of the figure denote the conceptual record sequence numbers used in the TOPOG data storage/retrieval system.

2.3.2 TOPOG File Preface Record

The TOPOG file preface record contains descriptors pertaining to the file; contents of the record are specified in detail in Table 2-4. The preface record contains the volume serial number of the TOPOG tape so that a program using the tape can check if the correct tape was assigned. It also contains the 20-character name of the TOPOG tape area, the date the file was generated, and an identification code for the organization that created it. The file preface record includes the latitude ϕ_T^S and longitude λ_T^W of the southwest corner of the corresponding TOPOG tape area, and the number N_R of TOPOG regions in the tape area. The last three items, when combined with the appropriate region longitude dimension $\Delta\lambda_R$, serve to define completely the tape area.

2.3.3 TOPOG Block Directory Records

Each TOPOG block in a TOPOG tape area is assigned a block category code K_B according to the following scheme:

(i) K_B = n (n a positive integer) implies the block corresponds to the block data record whose file sequence number is n (file sequence numbers are shown at the bottom of Figure 2-7); such blocks are called "standard" blocks.

(ii) K_B = 0 implies the block is not "standard" (i.e., it does not correspond to any block data record in the file) and the elevation of every point in the block is zero (i.e., mean sea level); such blocks are called "ocean" blocks.

(iii) K_B = -1 implies simply that the block is not "standard"; such blocks are called "missing" blocks. No elevation information, either implicit

Preface Record	Block Directory Record (District 1)	Block Directory Record (District 2)	. . .	Block Directory Record (District N_D)	Block Data Record	Block Data Record	. . .
0	1	2		N_D	N_D+1	N_D+2	

Figure 2-7. TOPOG terrain elevation file.

or explicit, is contained in the file for any interior point of a "missing" block (data for boundary points may be included in adjacent blocks).[1]

Programs reading a TOPOG terrain elevation file typically use a CDC Record Manager routine (GET) to extract a block data record frm the tape. The corresponding value of K_B provides the information needed to position the file to the proper record; however, the record length (in characters) must also be specified. To this end, we define a modified block category code K_B^* as follows. For "ocean" and "missing" blocks, we simply set $K_B^* = K_B$; for "standard" blocks, we define K_B^* by packing the corresponding block data record length (in 60-bit words) into the high-order (most significant) 30 bits of a CDC integer variable, and the record sequence number K_B into the low-order 30 bits. Note that it is still true that $K_B^*>0$ for "standard" blocks.

A TOPOG terrain elevation file contains one block directory record for each district in the corresponding tape area, these records being arranged in the order of increasing district index I_D as indicated in Figure 2-7. Each block directory record is 64 words long; word I_B (I_B = 1,2,...64) contains the modified block category code $K_B^*(I_B)$ for block I_B in the corresponding district. The record structure is shown in Table 2-5.

2.3.4 TOPOG Block Data Records

A TOPOG terrain elevation file contains one block data record for each "standard" block in the corresponding TOPOG tape area. Each block data record contains terrain elevation values for TOPOG grid points contained in the corresponding block. To save storage, elevation values are expressed in "ΔZ units" above a reference elevation Z_{REF} (which is expressed in ΔZ units above mean sea level). Both ΔZ and Z_{REF} depend on the terrain in the block to

---

[1] Typically, a block is not categorized as "missing" unless it includes some terrain above sea level, but there is no intrinsic necessity for this in the TOPOG data storage/retrieval system. Likewise, there is nothing intrinsic in the system that precludes a block's being categorized as "standard" when, in fact, all of its points are at sea level, or (since missing elevation values for individual grid points are coded in the storage scheme) when elevation values for all interior grid points are missing. In a practical sense, however, the TOPOG file generation program GENTOP is coded so that the latter two situations do not occur.

Table 2-4. TOPOG File Preface Record

Word	Description of Contents
1	VSN of TOPOG tape (10 characters)
2-3	Name of TOPOG tape area (20 characters)
4	Date TOPOG tape generated (10 characters)
5	ID of organization or agency generating TOPOG tape (10 characters)
6	Latitude of south boundary of TOPOG tape area (integer degrees north of equator)
7	Longitude of west boundary of TOPOG tape area (integer degrees east of prime meridian)
8	Number of TOPOG regions in TOPOG tape area (integer)

Table 2-5. TOPOG Block Directory Record

Word	Description of Contents
1	Modified category code $K_B^*(1)$ for block 1 in district
2	Modified category code $K_B^*(2)$ for block 2 in district
⋮	
64	Modified category code $K_B^*(64)$ for block 64 in district

which they refer, and are defined as follows. The elevation increment ΔZ is expressed in meters according to the scheme

$$\Delta Z = \begin{cases} 1 & (0 \leq Z_{MAX} - Z_{MIN} < 200) \\ 2 & (200 \leq Z_{MAX} - Z_{MIN} < 500) \\ 5 & (500 \leq Z_{MAX} - Z_{MIN} < 1000) \\ 10 & (1000 \leq Z_{MAX} - Z_{MIN} < 2000) \\ 20 & (2000 \leq Z_{MAX} - Z_{MIN} < 5000) \\ 50 & (5000 \leq Z_{MAX} - Z_{MIN}) \end{cases} \qquad (2.3.4\text{-}1)$$

where Z_{MAX} and Z_{MIN} are, respectively, the maximum and minimum grid point elevations (in meters) in the block. Note that ΔZ is akin to a contour interval for a topographic map. When ΔZ has been determined for a block, Z_{MIN} is expressed in ΔZ units and the reference elevation Z_{REF} is defined as

$$Z_{REF} = Z_{MIN} - 1 \qquad (2.3.4\text{-}2)$$

In the preceding scheme, all grid point elevations stored in a block data record are intrinsically positive integers. A zero elevation value is then used to indicate that the actual elevation of the corresponding grid point is missing. An examination of the conditions in (2.3.4-1) shows that at most 8 bits are required to store an elevation value. To conserve storage space, elevation values are packed sequentially into words as indicated in Figure 2-8, a procedure that is facilitated by the fact that every elevation value is non-negative. The number N_B of bits used to store each elevation value in a block data record is taken to be the least number required to store the largest elevation value. The number N_W of elevation values packed in each word is $[60/N_B]$, the greatest integer not exceeding $60/N_B$. Note that the packed values are left-justified in each word, any unused bits being located in the lowest-order (least significant) positions of the word.

The structure of a block data record is shown in Table 2-6. It begins with 10 words of information which give the latitude ϕ_B^S and longitude λ_B^W of the southwest corner of the corresponding block, and the longitude interval $\Delta\lambda_G$ between adjacent grid points in the block. Also included is the information needed to unpack the elevation values stored in the record and convert them into elevations above sea level. This consists of the elevation

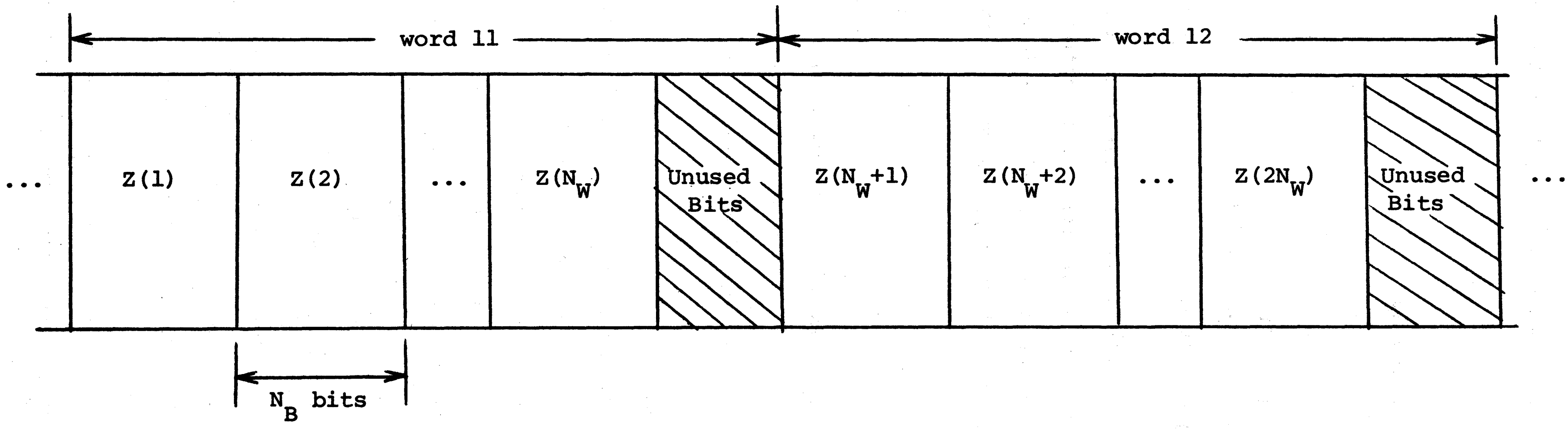


Figure 2-8. Packed terrain elevation values in block data record.

Table 2-6. TOPOG Block Data Record

Word	Description of Contents
1	Latitude of south boundary of TOPOG block (in 1/8-degree integer units north of equator)
2	Longitude of west boundary of TOPOG block (in 1/8-degree integer units east of prime meridian)
3	Longitude interval $\Delta\lambda_G$ between adjacent grid points (in integer seconds)
4	Elevation increment ΔZ characteristic of block (in integer meters)
5	Reference elevation Z_{REF} for block (in ΔZ integer units above MSL)--Z_{REF} is one ΔZ unit below elevation of lowest grid point in block
6	Elevation of highest grid point in block (in ΔZ units above Z_{REF})
7	Number N_B of bits used to store each elevation value (integer)
8	Number of missing grid point elevations in block (integer)
9	Date block data record generated (10 characters)
10	ID of elevation data source (10 characters)
11	Packed elevations of grid points 1,2,3,...,22801 (in ΔZ-units above Z_{REF})
⋮	

increment ΔZ, the reference elevation Z_{REF}, and the number N_B of bits used to store each elevation value. Other items contained in the "header" words include the maximum grid point elevation in the block, the number of grid points in the block for which elevation values are missing, the date the block data record was generated, and a 10-character identifier of the elevation data source. In the event software is created to revise TOPOG files, the generation date and source ID may vary from one block to another.

2.3.5 TOPOG Directory File

The TOPOG directory file TOPDRY includes (i) a region directory that contains status information for each of the 3060 TOPOG regions, and (ii) a list of tape area names for each terrain elevation file in the TOPOG data base. Like a terrain elevation file, the directory file is stored on a separate magnetic tape and is written using CDC Record Manager routines as a sequential file of W-type logical records that are internally blocked. The vsn of the tape is TG0000.

The structure of TOPDRY is shown in Figure 2-9. It starts with the 612-word TOPOG region directory, which is described in Section 2.3.5.1. The region directory is followed by a sequence of 10 tape area name records, which are described in Section 2.3.5.2.

Region Directory Record	Tape Area Name Record 1	Tape Area Name Record 2	. . .	Tape Area Name Record 10

Figure 2-9. TOPOG directory file TOPDRY.

2.3.5.1 TOPOG Region Directory

Relative to a particular TOPOG data base, each TOPOG region is assigned a region category code K_R according to a scheme analogous to that used for assigning category codes to blocks in a TOPOG tape area. For I_R = 1,2, ...,3060:

(i) $K_R(I_R) = n$ (n a positive integer) implies region I_R is contained in tape area n corresponding to a terrain elevation file in the given TOPOG data base; such regions are called "standard" regions.

(ii) $K_R(I_R) = 0$ implies region I_R is not "standard" (i.e., it is not contained in a tape area for any terrain elevation file in the particular TOPOG data base) and the elevation of every point in the region is zero (i.e., mean sea level); such regions are called "ocean" regions.

(iii) $K_R(I_R) = -1$ implies simply that region I_R is not "standard"; such regions are called "missing" regions. No elevation information, either implicit or explicit, is contained in the particular data base for any interior point of a "missing" region (elevation information for boundary points may be included in adjacent regions).[2]

The category codes defined above form the basis for a TOPOG region directory. Because this directory is stored in central memory by programs that generate or read TOPOG terrain elevation files, there is a need to conserve storage space by packing category code values. To this end, we define a biased region category code K_R^* as

$$K_R^*(I_R) = K_R(I_R) + 1 \quad (I_R = 1,2,\ldots,3060) \qquad (2.3.5.1\text{-}1)$$

[2]The fact that a region is "missing", relative to some particular TOPOG data base, may simply reflect the fact that the region has not been categorized; it could indeed have zero elevation at all of its points. The task of identifying and categorizing all possible "ocean" regions is not a trivial one; or, the distinction between "ocean" and "missing" may be regarded as irrelevant in the case of a particular data base. Likewise, a region lying entirely within an ocean may in fact be categorized as "standard" because it is contained in a multi-region tape area for some terrain elevation file in the TOPOG data base.

This simple expedient eliminates the need for storing and unpacking negative numbers. It also reduces the storage requirement to 12 bits per value, which permits five K_R^*-values to be packed in each 60-bit CDC word. The sequence of 3060 biased region category codes constitute the TOPOG region directory. The packing scheme is indicated in Figure 2-10; it requires a total of 612 words.

2.3.5.2 Tape Area Name Records

A tape area name record is 612 words long and contains a sequence of 306 two-word (20-character) "names", each corresponding to a TOPOG region. If a region is a standard region, i.e., if it is included in the tape area for some terrain elevation file in the TOPOG data base, then the name is that of the tape area. Otherwise, for ocean and missing regions, the 20-character name is blank-filled. In the data unit comprised of the sequence of all 10 tape area name records, the names are arranged in the order of increasing global region index.

2.3.5.3 Remarks

At the outset of Section 2.3.5.1, it was stated that region category codes are "relative to a particular TOPOG data base"; that same qualification extends, of course, to the TOPOG region directory. Several installations may maintain their own individual TOPOG data bases, each independent of the other. In general, a particular data base will consist of a combination of terrain elevation data files generated by the maintaining installation and acquired from other installations. Multi-region tape areas, not being fixed by the TOPOG data storage/retrieval system, may also be defined differently by different installations that generate TOPOG files. The point to be made here is that TOPOG data bases may differ from one installation to another, and to be of maximum use, each TOPOG region directory must conform exactly to the collection of terrain elevation files to which it applies.

As well as varying from one installation to another, the contents of a TOPOG data base may vary with time at any given installation. Terrain elevation files may be generated or obtained from other installations and added to the data base. Files may be lost or damaged, or otherwise removed from a data base. Also, missing regions may be categorized as ocean (or vice versa, in order to correct a mistake). Thus, there is a need to revise or update a given TOPOG directory file from time to time. When generating a

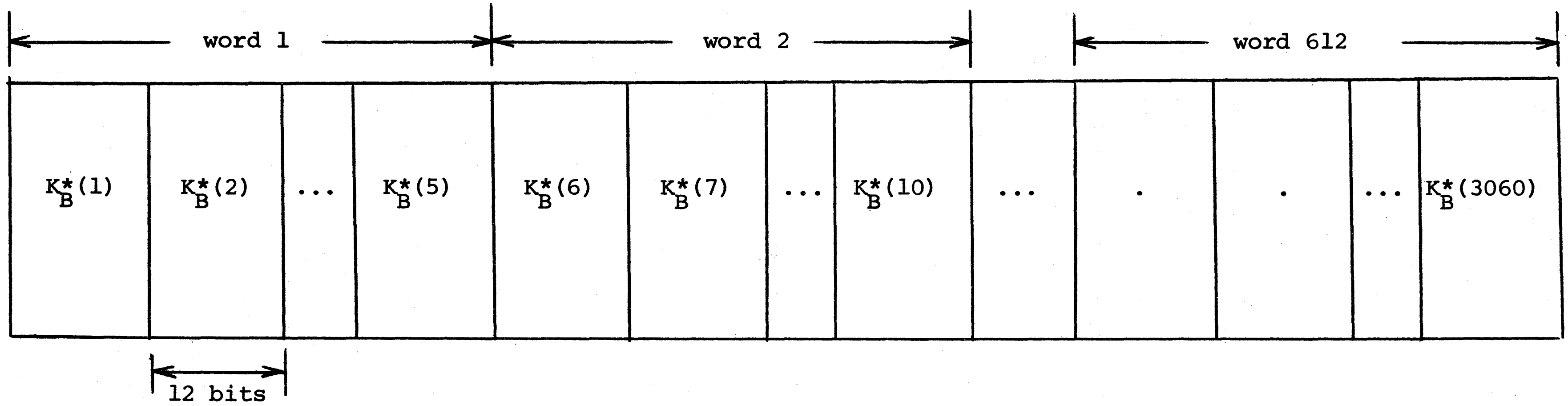


Figure 2-10. TOPOG region directory record.

terrain elevation file, the required revision is done automatically by program GENTOP. Other needed updates are performed by a separate file maintenance program (FIXDRY), which is described in Section 4. In the case of both GENTOP and FIXDRY, the contents of the TOPOG directory file TOPDRY are written to a word-addressable disk file REGDRY. The necessary revisions are then made in REGDRY, and the updated version of the directory file is written back to the tape file TOPDRY.

2.4 Basic Data Extraction Algorithms

We conclude our description of the TOPOG data base with an illustration of how its fundamental features are used in estimating the elevation $Z(\phi,\lambda)$ of a point with arbitrarily specified latitude ϕ and longitude λ. Everywhere in this discussion, the symbol [x] is used to denote the largest integer not exceeding x.

(1) <u>Identify the TOPOG regon containing (ϕ,λ).</u> The zone index I_Z of the region is given by

$$I_Z = \left[\frac{90+\phi}{5}\right] + 1 \qquad (2.4\text{-}1)$$

where ϕ is expressed in degrees north of the equator. The local region index I_R^C is given by

$$I_R^C = \left[\frac{180+\lambda}{\Delta\lambda_R(I_Z)}\right] + 1 \qquad (2.4\text{-}2)$$

where λ is expressed in degrees east of the prime meridian and $\Delta\lambda_R(I_Z)$ is the longitude dimension (in degrees) for regions in zone I_Z. The global region index I_R is then calculated using (2.2.2-3). The biased region category code $K_R^*(I_R)$ for region I_R is now extracted from the region directory, and the (unbiased) category code $K_R(I_R)$ is calculated and examined. If $K_R(I_R) = -1$, then $Z(\phi,\lambda)$ cannot be determined; if $K_R(I_R) = 0$, then $Z(\phi,\lambda) = 0$. In either of these cases, we are done. If, on the other hand, $K_R(I_R)$ is a positive integer, then region I_R is covered by a terrain elevation file in the TOPOG data base, and the value of $K_R(I_R)$ serves as a pointer to that file. Extract the tape area's south boundary latitude ϕ_T^S and west boundary longitude λ_T^W from the preface record of that file.

(2) Identify the TOPOG district containing (ϕ,λ). The row index I_D^R of the district is given by

$$I_D^R = \left[\phi - \phi_T^S\right] + 1 \qquad (2.4\text{-}3)$$

and the column index I_D^C is

$$I_D^C = \left[\frac{\lambda-\lambda_T^W}{\Delta\lambda_D}\right] \qquad (2.4\text{-}4)$$

where $\Delta\lambda_D = \Delta\lambda_R(I_R)$ is the district longitude dimension. The district index I_D is then calculated using (2.2.4-2), and the appropriate block directory record is extracted from the terrain elevation file. Evaluate the district boundary coordinates

$$\phi_D^S = \phi_T^S + (I_D^R-1) \qquad (2.4\text{-}5)$$

and

$$\lambda_D^W = \lambda_T^W + (I_D^C-1) \times \Delta\lambda_D \qquad (2.4\text{-}6)$$

where these are expressed in degrees.

(3) Identify the TOPOG block containing (ϕ,λ). The row index I_B^R of the block is given by

$$I_B^R = \left[8(\phi-\phi_D^S)\right] + 1 \qquad (2.4\text{-}7)$$

and the block column index I_B^C is

$$I_B^C = \left[\frac{\lambda-\lambda_D^W}{\Delta\lambda_B}\right] + 1 \qquad (2.4\text{-}8)$$

where $\Delta\lambda_B = \Delta\lambda_D/8$ is the block longitude dimension. The block index I_B is then calculated using (2.2.5-2). The modified block category code $K_B(I_B)$ in the relevant block directory record is now examined. If $K_B^*(I_B) = -1$, then $Z(\phi,\lambda)$ cannot be determined; if $K_B^*(I_B) = 0$, then $Z(\phi,\lambda) = 0$. In either of these cases, we are done. If, on the other hand, $K_R^*(I_B)$ is a positive integer, then block I_B corresponds to a block data record in the terrain elevation file. The record length and sequence number are then unpacked from $K_R^*(I_B)$, and the relevant block data record is extracted from the file. Evaluate the block boundary coordinates

$$\phi_B^S = \phi_D^S + (I_B^R - 1)/8 \tag{2.4-9}$$

and

$$\lambda_B^W = \lambda_D^W + (I_B^C - 1) \times \Delta\lambda_B \tag{2.4-10}$$

where these are expressed in degrees.

(4) Extract corner elevations of TOPOG cell containing (ϕ, λ). The row index $I_G^R(1)$ of the southwest corner of the cell is given by

$$I_G^R(1) = \left[\frac{\phi - \phi_B^S}{\Delta\phi_G} \right] + 1 \tag{2.4-11}$$

where $\Delta\phi_G$ = 3" is the latitude grid interval. The column index $I_G^C(1)$ of that grid point is

$$I_G^C(1) = \left[\frac{\lambda - \lambda_B^W}{\Delta\lambda_G} \right] + 1$$

where $\Delta\lambda_G$ is the longitude grid interval. The grid point index $I_G(1)$ of the southwest corner of the cell is then calculated using (2.2.5-8). Indexes of the remaining corners are evaluated from

$$I_G(2) = I_G(1) + 1, \tag{2.4-12a}$$

$$I_G(3) = I_G(1) + 151, \tag{2.4-12b}$$

$$I_G(3) = I_G(3) + 1. \tag{2.4-12c}$$

Elevations Z(1), Z(2), Z(3), Z(4) of the cell corners are unpacked from the block data record, and cell boundary coordinates

$$\phi_G^S = \phi_B^S + (I_G^R(1) - 1) \times \Delta\phi_G \tag{2.4-13}$$

and

$$\lambda_G^W = \lambda_B^W + (I_G^C(1)-1) \times \Delta\lambda_G \qquad (2.4\text{-}14)$$

are evaluated.

(5) Estimate elevation $Z(\phi,\lambda)$. The elevation $Z(\phi,\lambda)$ at (ϕ,λ) is estimated by applying the standard bilinear interpolation formula to the elevations of the cell corners:

$$Z(\phi,\lambda) = (1-r_\phi)(1-r_\lambda)Z(1) + r_\phi(1-r_\lambda)Z(2) + r_\lambda(1-r_\phi)Z(3) + r_\phi r_\lambda Z(4) \qquad (2.4\text{-}15)$$

where

$$r_\phi = \frac{\phi-\phi_G^S}{\Delta\phi_G} \qquad (2.4\text{-}16a)$$

and

$$r_\lambda = \frac{\lambda-\lambda_G^W}{\Delta\lambda_G} \qquad (2.4\text{-}16b)$$

In the formulas for calculating indexes, note that if a grid point is located on the south or west boundary of a geographical element, then it is regarded, in the data extraction scheme, as belonging to that element. On the other hand, a grid point lying on the north or east boundary of a geographical element is regarded as belonging to the adjacent element.

3. THE AUXILIARY BOXTOP DATA BASE

3.1 Overview

The TOPOG data base is an efficient global system for archiving digital terrain elevation data. In applications, however, there are often situations where the use of TOPOG as a "working" or operational data base is not efficient. The degree of this inefficiency may range anywhere from the tolerably slight to a level that prevents the practical use of TOPOG altogether. A particularly severe case is illustrated in Figure 3-1, where a user wishes to plot terrain elevation profiles automatically along a series of radials drawn from a fixed point. Such a procedure is utilized, for example, by computer programs that assist in the design and evaluation of radio communication systems. In the case shown, the radials cross four TOPOG tape areas, whose boundaries are represented by heavy lines. TOPOG blocks are indicated by lighter lines. Each time a radial crosses a block boundary, the relevant block data record must be extracted from a TOPOG tape and read into memory. Each time a radial crosses a tape area boundary, a different TOPOG tape is needed. The difficulty in using the TOPOG data base to generate the terrain profiles is evident.

The problem is really two-fold: the sequential structure of the TOPOG files, and the fact that the required records are contained in different files stored on separate tapes. The problem could be alleviated, but not eliminated, by writing the TOPOG records in large random-access files stored on magnetic disks. Record retrieval from those files would be much more efficient, and since the geographical counterpart of such a disk file could be 5-6 times larger than a TOPOG region, the problem of needed records being contained in different files would occur less often. But that problem would still exist; the heavy lines in Figure 3-1 might just as well represent the boundaries of postulated "TOPOG file areas."

Such problems in using TOPOG as a working data base have been largely overcome by a procedure whose basic features are as follows. First, the data-base user defines an area of interest, for some particular application, by specifying a pair of boundary parallels and a pair of boundary meridians. This information is for a computer program (GENBOX), which adjusts (if necessary) the bounding parallels and meridians so that they (i) include the

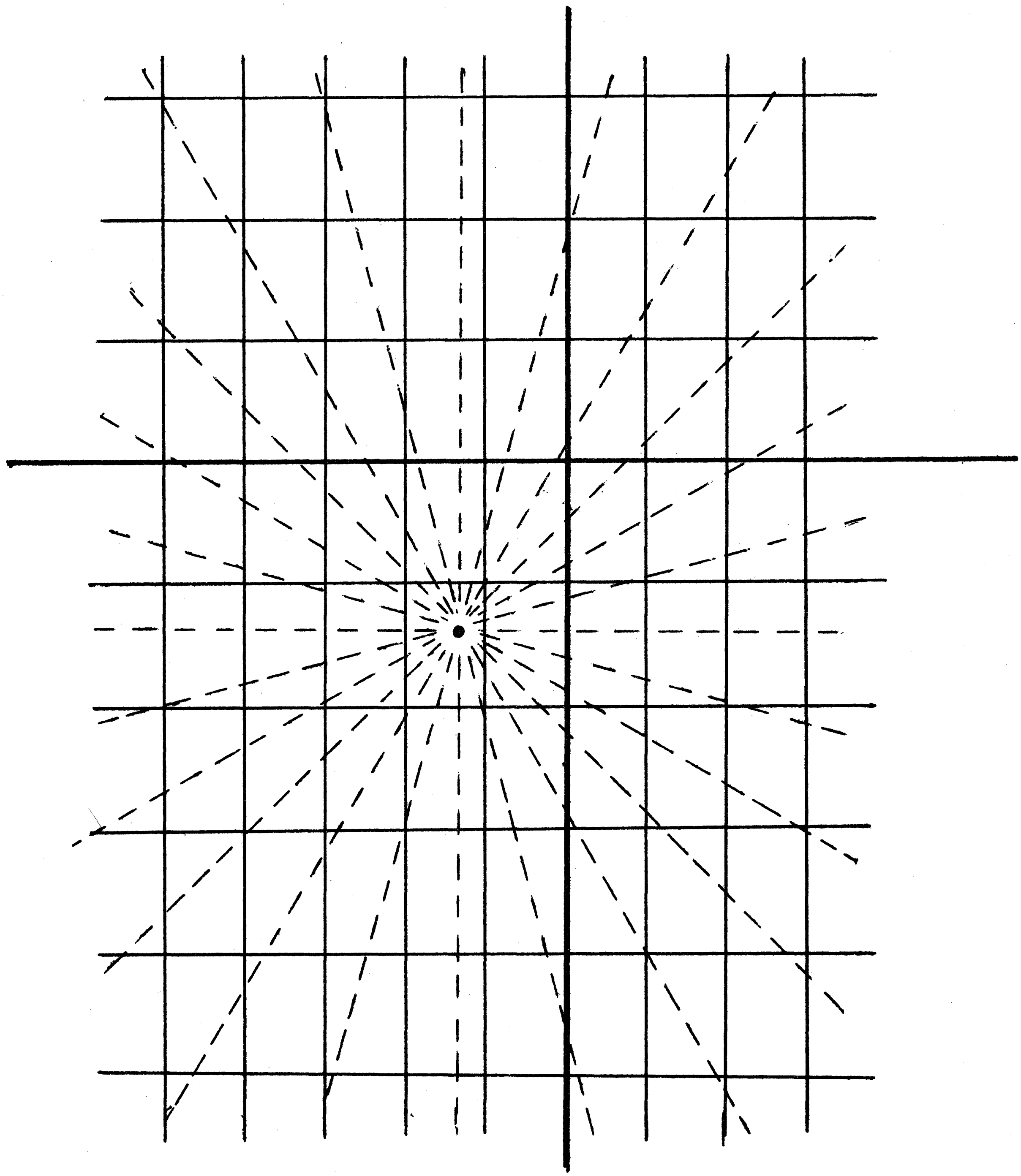


Figure 3-1. Location of terrain elevation profiles in a hypothetical application of the TOPOG data base.

user-defined area, and (ii) coincide with TOPOG district boundaries. For each standard TOPOG block in this adjusted area, GENBOX then extracts the corresponding block data record from the TOPOG data base and writes it to a word-addressable file (BOXTOP) stored on magnetic disk. GENBOX also generates, and writes to BOXTOP, a set of directory records that facilitate the retrieval of terrain elevation data from the file. The word-addressable BOXTOP disk file is then used as the "working" terrain elevation data base in the particular application.

A detailed description of the organization and structure of a BOXTOP file is contained in Sections 3.2 and 3.3, and the program GENBOX that generates BOXTOP files is described in Section 6.

3.2 BOXTOP Geographical Elements

The geographical counterpart of a BOXTOP terrain elevation file is called a BOXTOP disk area. As described in Section 3.1, this area is bounded by a single pair of parallels and a single pair of meridians that everywhere coincide with TOPOG district boundaries. A BOXTOP disk area thus consists of a set of TOPOG districts. By definition, the number of such districts may not exceed 100. This number is large enough to include most areas of practical interest, yet small enough that the corresponding data can be stored on one dual density CDC 844-41 removable disk pack. Within the limits imposed by the 100-district maximum size, and by the requirement that its bounding parallels and meridians coincide with TOPOG district boundaries, a BOXTOP disk area may be any size or shape. It may, for example, straddle the 180th meridian, and include portions of more than one of the TOPOG latitude intervals listed in Table 2-2.

For a given BOXTOP disk area, we use the following notation for boundary coordinates:

$$\phi_A^S = \text{south boundary latitude of disk area,} \tag{3.2-1}$$
$$\phi_A^N = \text{north boundary latitude of disk area,} \tag{3.2-2}$$
$$\lambda_A^W = \text{west boundary longitude of disk area,} \tag{3.2-3}$$
$$\lambda_A^E = \text{east boundary longitude of disk area.} \tag{3.2-4}$$

We then define the latitude dimension $\Delta\phi_A$ and longitude dimension $\Delta\lambda_A$ of a BOXTOP disk area as

$$\Delta\phi_A = \phi_A^N - \phi_A^S \tag{3.2-5}$$

and

$$\Delta\lambda_A = \lambda_A^E - \lambda_A^W \tag{3.2-6}$$

When the disk area straddles the 180th meridian, one must exercise caution in calculating $\Delta\lambda_A$ so as to avoid including an extra 360°.

The districts comprising a BOXTOP disk area are rather obviously arranged in west/east rows. But because the disk area may lie in more than one TOPOG latitude interval, in which case the district longitude interval is not the same for all rows, these districts are not necessarily arranged in columns. For this reason, districts within a BOXTOP disk area are indexed according to a scheme analogous to that used for indexing TOPOG regions, rather than the one used for districts within a TOPOG tape area. The essential features of this scheme are illustrated in Figure 3-2. District rows (analogous to TOPOG zones) are numbered sequentially northward from the south boundary of the disk area. Note that the number N_D^R of rows is numerically equal to $\Delta\phi_A$ expressed in degrees. Within any particular row, districts are numbered sequentially eastward from the west boundary of the disk area. A particular district within a BOXTOP disk area may then be identified by specifying its row index J_D^R and its sequence number J_D within the row. The number of districts in row J_D^R is denoted by $N_D^C(J_D^R)$ and is given by

$$N_D^C(J_D^R) = \Delta\lambda_A/\Delta\lambda_D(J_D^R) \tag{3.2-7}$$

where $\Delta\lambda_D(J_D^R)$ is the longitude dimension of districts in row J_D^R. To facilitate data storage and retrieval, the districts within a BOXTOP disk area are arranged in the following sequence, where each district is denoted by the index pair (J_D^R, J_D^C):

$$(1,1),(1,2),\ldots,(2,1),(2,2),\ldots$$

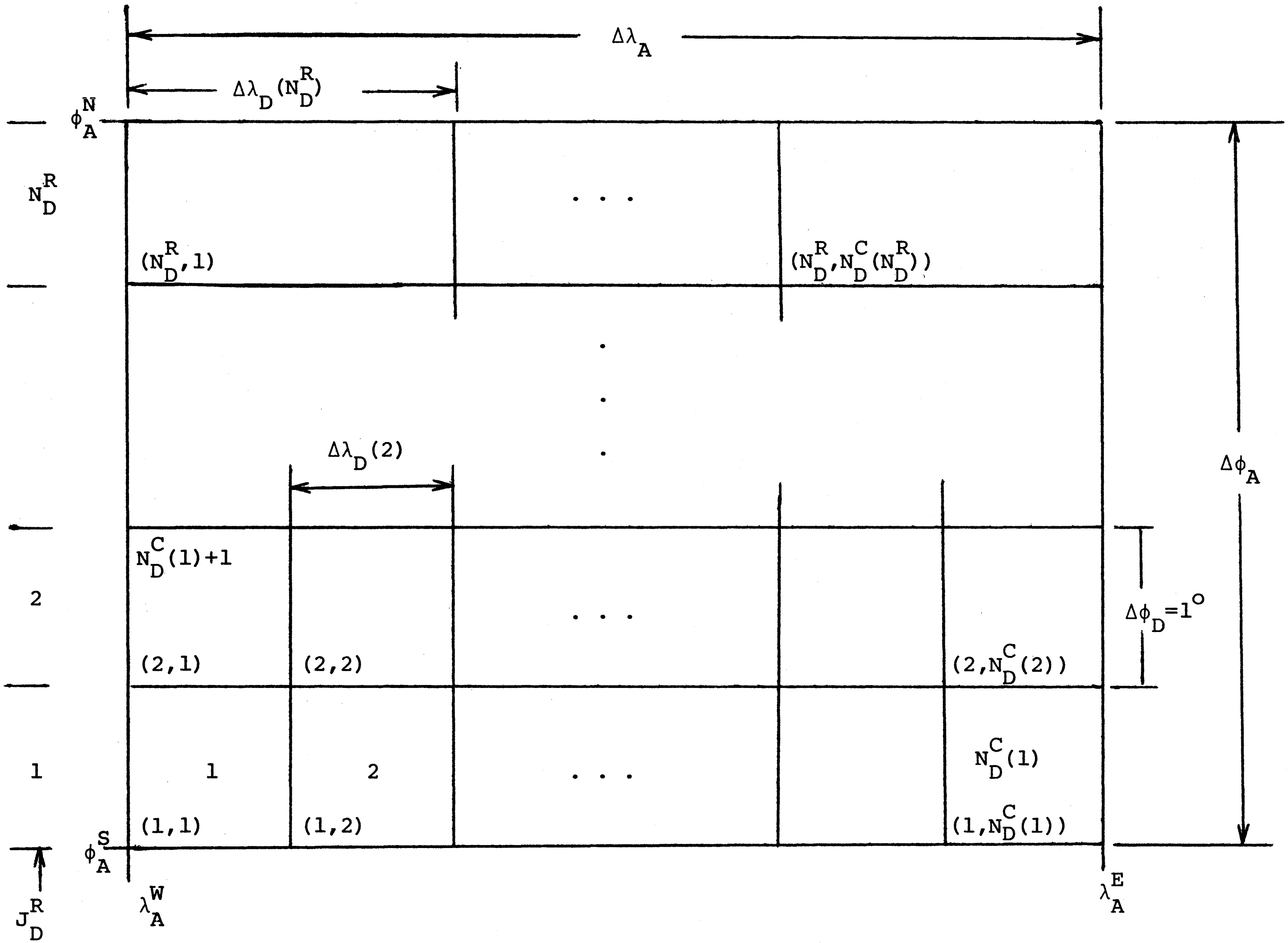


Figure 3-2. BOXTOP disk area and district indexing scheme.

A district may then be identified by its BOXTOP district index J_D, a positive integer denoting the position of the district in the above sequence. For district J_D^C in row J_D^R, we have the relation

$$J_D = J_D^C + \sum_{I_D^R=1}^{J_D^R-1} N_D^C(I_D^R) \qquad (3.2\text{-}8)$$

where $N_D^C(I_D^R)$ is given by (3.2-7), and the summation is neglected when $J_D^R = 1$.

Smaller BOXTOP geographical elements (blocks, etc.) and associated indexing schemes are identical to those described in Section 2.2 for the TOPOG system.

3.3 BOXTOP Data Structures

3.3.1 BOXTOP File Structure

As described in Section 3.1, BOXTOP is a word-addressable file stored on magnetic disk. As such, it is written and read by CDC Record Manager routines, each record being characterized by a user-defined starting word address and record length. The BOXTOP file structure, with component records arranged according to starting word address, is shown in Figure 3-3. The file includes a file preface record containing information about the file and corresponding disk area, a longitude dimension record containing the value of the district longitude dimension $\Delta\lambda_D$ for each row of districts in the disk area, and a district directory record containing pointers to block directory records. It also contains, for each district in the BOXTOP disk area, a block directory record containing status information about each TOPOG block in the district. This information includes pointers to relevant block data records. Finally, the BOXTOP file contains a collection of TOPOG block data records, one corresponding to each standard TOPOG block in the disk area. Owing to the order of its generation, each block directory record "follows" the block data records to which it applies (for a word-addressable file, this is not a disadvantage). Detailed descriptions of record contents are contained in Sections 3.3.2-3.3.6.

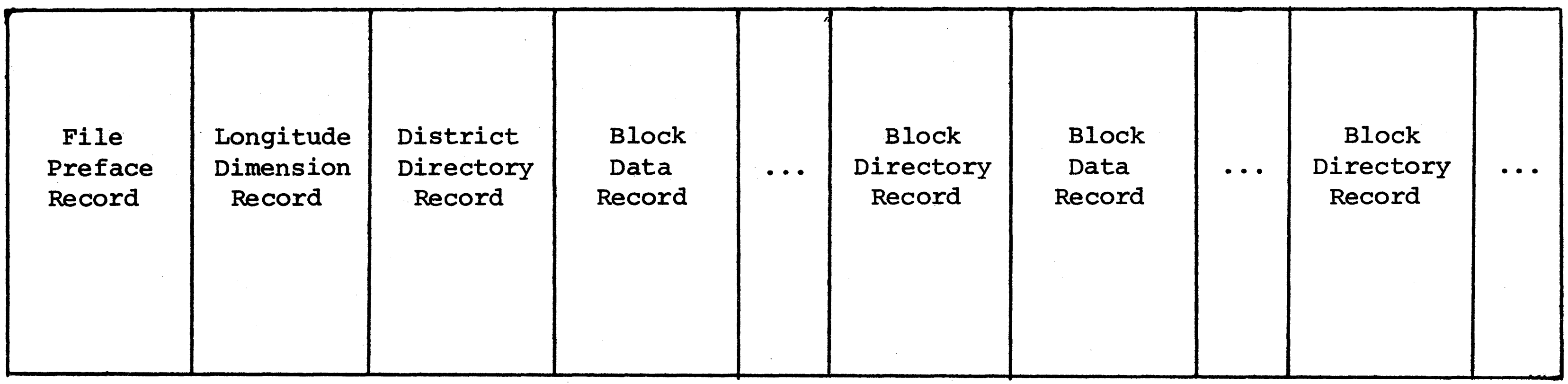


Figure 3-3. BOXTOP file structure.

3.3.2 BOXTOP File Preface Record

The BOXTOP file preface record contains a 20-character (or less) user-defined name of the BOXTOP disk area; if the user does not specify a name, this field is blank-filled. The record also contains the boundary coordinates of the disk area, the date the BOXTOP file was created, and a 10-character identifier of the organization or installation that created it. The fields of the preface record are described in Table 3-1.

Table 3-1. BOXTOP File Preface Record

Word	Description of Contents
1-2	Name of BOXTOP disk area (20 characters)
3	South boundary latitude of BOXTOP disk area (degrees north of equator)
4	North boundary latitude of BOXTOP disk area (degrees north of equator)
5	West boundary longitude of BOXTOP disk area (degrees east of prime meridian)
6	East boundary longitude of BOXTOP disk area (degrees east of prime meridian)
7	Date BOXTOP file generated (10 characters)
8	ID of generating organization (10 characters)

3.3.3 BOXTOP Longitude Dimension Record

As indicated in Table 3-2, word J_D^R of the BOXTOP longitude dimension record contains the longitude dimension $\Delta\lambda_D(J_D^R)$, expressed in degrees, of districts in row J_D^R of the BOXTOP disk area. The record is 100 words in length, since the number 100 is an upper bound on the number of district rows in a disk area. Contents of any unused words at the end of the record are undefined.

Table 3-2. BOXTOP Longitude Dimension Record

Word	Description of Contents
1	Longitude dimension of districts in row 1 of BOXTOP disk area (degrees)
2	Longitude dimension of districts in row 2 of BOXTOP disk area (degrees)
⋮	⋮

3.3.4 BOXTOP District Directory Record

As shown in Table 3-3, word J_D of the BOXTOP district directory record contains the starting word address of the block directory record for district J_D in the BOXTOP disk area. The record is 100 words in length, since the disk area may contain as many as 100 districts. Any unused words at the end of the record contain the value -1.

Table 3-3. BOXTOP District Directory Record

Word	Description of Contents
1	Starting word address of block directory record for district 1
2	Starting word address of block directory record for district 2
⋮	⋮

3.3.5 BOXTOP Block Data Records

BOXTOP block data records are copied from a TOPOG terrain elevation file. Their contents have been described in Section 2.3.4.

3.3.6 BOXTOP Block Directory Records

A BOXTOP file contains a block directory record for each district in the corresponding disk area. Such a record is the analog of the block directory record in a TOPOG terrain elevation file. For any given district in the disk area, the corresponding block directory record contains, for each block J_B in the district, an integer value that (i) points to the block data record for that block, (ii) indicates that every point of the block is at zero elevation, or (iii) indicates that the BOXTOP file contains no elevation information for the block.

The contents of a BOXTOP block directory record are defined in essentially the same way as those of a TOPOG block directory record. Each block in a BOXTOP disk area is categorized and assigned a <u>category code</u> according to the following scheme:

(i) $K_B>0$ if and only if the block corresponds to some block data record in the BOXTOP file. In this case, the block is called a "standard" block, and the value of K_B serves as a pointer to the corresponding block data record; specifically, it is the starting word address of that record in the BOXTOP file. Every standard block in a given BOXTOP disk area is also a standard block (in the TOPOG sense) in some TOPOG tape area.

(ii) $K_B=0$ implies the block is not standard (i.e., it does not correspond to any block data record in the BOXTOP file) and that every point in the block has elevation zero. In this case, the block is called an "ocean" block. Every ocean block in a given BOXTOP disk area is either an ocean block in some TOPOG tape area or a block in some TOPOG ocean region.

(iii) $K_B=-1$ implies only that the block is not standard; nothing is implied about the elevation of any of its points. In this case, the block is called a "missing" block. Every missing block in a given BOXTOP disk area is either a missing block in some TOPOG tape area or a block in some TOPOG missing region.

Because the length of block data records is not fixed, the starting word address of such a record is not sufficient information to extract that record from a BOXTOP file; the record length is also needed. To this end we define, for each block in a BOXTOP disk area, a <u>modified category code</u> K_B^* as follows. For ocean and missing blocks, we set $K_B^*=K_B$; for standard blocks, K_B^*

is formed by packing the starting word address into the high order (most significant) 30 bits of a CDC word, and the record length (in words) into the low order 30 bits. Note that the result still "looks" like a positive integer.

The block directory record for a particular district in a BOXTOP disk area contains the modified category codes for all blocks in that district. Specifically, as indicated in Table 3-4, word I_B contains $K_B^*(I_B)$.

Table 3-4. BOXTOP Block Directory Record

Word	Description of Contents
1	Modified category code $K_B^*(1)$ for block 1
2	Modified category code $K_B^*(2)$ for block 2
⋮	⋮
64	Modified category code $K_B^*(64)$ for block 64

3.4 Basic Data Extraction Algorithms

In this section, we illustrate some basic data extraction procedures by describing how data in a BOXTOP file are used to estimate the elevation $Z(\phi,\lambda)$ of an arbitrarily specified point in the corresponding disk area. This description is analogous to that in Section 2.4 for the TOPOG data base.

(1) Identify the district containing (ϕ,λ). The row index J_D^R of the district is given by

$$J_D^R = [\phi - \phi_A^S] + 1 \tag{3.4-1}$$

and the sequence number J_D^C of the district in that row is

$$J_D^C = \left[\frac{\lambda-\lambda_A^W}{\Delta\lambda_D(J_D^R)} \right] + 1 \tag{3.4-2}$$

where $\Delta\lambda_D(J_D^C)$ is the district longitude dimension for row J_D^R. The district index J_D is then calculated from (3.2-8). The starting word address of the block directory record for district J_D is obtained from the district directory record, and the relevant block directory record is extracted from the BOXTOP file. District boundary coordinates (in degrees) are evaluated from

$$\phi_D^S(J_D) = \phi_A^S + (J_D^R-1) \qquad (3.4\text{-}3)$$

and

$$\lambda_D^W(J_D) = \lambda_A^W + (J_D^C-1) \times \Delta\lambda_D(J_D^R) \qquad (3.4\text{-}4)$$

(2) Identify the block containing (ϕ,λ). The row index J_B^R of the block is given by

$$J_B^R = \left[8(\phi-\phi_D^S)\right] + 1 \qquad (3.4\text{-}5)$$

and the column index J_B^C of the block is

$$J_B^C = \left[\frac{\lambda-\lambda_D^W}{\Delta\lambda_B}\right] + 1 \qquad (3.4\text{-}6)$$

where $\Delta\lambda_B = \Delta\lambda_D(J_D^R)/8$ is the longitude dimension of the block. The block index J_B is then calculated from (2.2.5-2). The modified block category code $K_B^*(J_B)$ is extracted from the block directory record and examined. If $K_B^*(J_B)=0$, then $Z(\phi,\lambda)=0$; if $K_B(J_B)=-1$, then $Z(\phi,\lambda)$ cannot be evaluated. In either case, we are finished. Otherwise, if $K_B^*(J_B)>0$, the starting word address and record length of the corresponding block data record are unpacked from $K_B^*(J_B)$, and that record is extracted from the BOXTOP file.

(3) The remaining procedures are identical to those described in Section 2.4 for the TOPOG data base, and will not be described further here.

4. TOPOG DIRECTORY FILE MAINTENANCE: PROGRAM FIXDRY

4.1 Introduction

In Section 2.3.5.3, it was pointed out that the contents of a TOPOG data base at one installation may differ from those at another installation. Furthermore, at any given installation, the contents of a TOPOG data base will generally vary with time. Additional terrain elevation files may be generated or acquired from other installations, or qualifying regions may be categorized as "ocean". Also, tapes containing terrain elevation files may be damaged or lost, or otherwise removed from the data base.

When a terrain elevation file is generated by GENTOP, the TOPOG directory file is automatically updated. A separate program (FIXDRY) has been written for updating the directory file to account for other changes in the content of a TOPOG data base. This program also generates an "initial version" of the directory file (the first step in creating a TOPOG data base) and prints a summary containing status information for each of the 3060 TOPOG regions. A concise description of the procedures performed by FIXDRY follows in Section 4.2.1.

4.2 User's Guide to FIXDRY

4.2.1 Overview

FIXDRY is a program for maintaining the TOPOG directory file. The contents and structure of this file are described in Section 2.3.5. FIXDRY performs any of the following procedures:

(1) It creates an "initial version" of the TOPOG directory file; i.e., one in which all TOPOG regions are categorized as "missing" and all tape area names are blank-filled. Generating such a file is the initial step in establishing a TOPOG data base.

(2) It updates an existing TOPOG directory file to account for the addition of a specified terrain elevation file (tape) or an "ocean" region to the data base. Prior to the update, all affected TOPOG regions must be in the "missing" category. In adding a terrain elevation file, FIXDRY software

requests the TOPOG tape, extracts pertinent data from the preface record, then updates the region directory and writes the tape area name to the directory file.

(3) It updates an existing TOPOG directory file to account for the deletion of a specified terrain elevation file (tape) or an "ocean" region from the data base. The update returns all affected TOPOG regions to the "missing" category. In deleting a terrain elevation file, FIXDRY does not use the tape (indeed, it may not be available), but the user must specify its vsn. The corresponding tape area name is replaced with blanks.

(4) It prints a TOPOG region summary which lists, for all TOPOG regions, the region index, boundary coordinates, category title, and corresponding tape area name. Sample region summary output is included in Figure 4-1.

4.2.2 FIXDRY Input Data

Input data to FIXDRY consists of a title card and one or more "action cards", each of which directs FIXDRY to perform one of the procedures described in Section 4.2.1. The title card must precede all "action" cards, which may occur in any order. Blanks are ignored. The contents and format of input data cards are as follows.

(1) Title Card

The first card in the input deck is assumed to be the title card. Up to 80 characters of title information may be entered. To identify the job uniquely, the title is printed on every output page along with the date and time.

(2) CREATE card

The keyword CREATE is used to instruct FIXDRY to create an initial version of the TOPOG directory file, as described in Section 4.2.1. WARNING: the erroneous inclusion of a CREATE card in the input data for a FIXDRY run may result in the destruction of an existing TOPOG directory file.

```
TOPOG REGION DIRECTORY FILE MAINTENANCE                                    83/08/29.   14.54.37.        PAGE     1
TOPOG DIRECTORY UPDATE.

              TOPOG DIRECTORY UPDATE.
              ADD,TAPE,2628
              DELETE,OCEAN,2629
              DELETE,OCEAN,2632
              ADD,OCEAN,2623
              ADD,OCEAN,2625
              ADD,OCEAN,2624
              PRINT
         END OF INPUT DATA CARDS
```

Figure 4-1. Output from a typical FIXDRY run. Only the title page and three sample pages of data from the TOPOG region summary are illustrated.

```
TOPOG REGION DIRECTORY FILE MAINTENANCE                                   80/08/29.   14.54.37.      PAGE    2
TOPOG DIRECTORY UPDATE.

FIXDRY INPUT DATA SUMMARY
*************************

TITLE:  TOPOG DIRECTORY UPDATE.

CREATE NEW TOPOG DIRECTORY FILE:  NO

PRINT SUMMARY OF CONTENTS OF TOPOG DIRECTORY FILE:  YES

DIRECTORY MODIFICATIONS:

     DELETE    OCEAN     2629
     DELETE    OCEAN     2632
     ADD       OCEAN     2623
     ADD       OCEAN     2624
     ADD       OCEAN     2625
     ADD       TAPE      2628
```

Figure 4-1. (Continued).

```
TOPOG REGION DIRECTORY FILE MAINTENANCE                                  80/08/29.   14.54.37.      PAGE    3
TOPOG DIRECTORY UPDATE.

TTTTTTTTT   000000000   PPPPPPPPP   000000000   GGGGGGGGG
    T       0       0   P       P   0       0   G
    T       0       0   P       P   0       0   G
    T       0       0   P       P   0       0   G
    T       0       0   PPPPPPPPP   0       0   G    GGGGG
    T       0       0   P           0       0   G        G
    T       0       0   P           0       0   G        G
    T       000000000   P           000000000   GGGGGGGGG

                 DIGITAL TERRAIN ELEVATION DATA

          * * * * * * * * * * * * * * * * * * * *
          *                                     *
          *                                     *
          *        TOPOG REGION SUMMARY         *
          *                                     *
          *                                     *
          * * * * * * * * * * * * * * * * * * * *
```

Figure 4-1. (Continued).

TOPOG REGION SUMMARY

ZONE 01 90 S - 85 S

REGION	LONGITUDE	TAPE AREA NAME	CATEGORY
0001	180 W - 156 W		MISSING
0002	156 W - 132 W		MISSING
0003	132 W - 108 W		MISSING
0004	108 W - 84 W		MISSING
0005	84 W - 60 W		MISSING
0006	60 W - 36 W		MISSING
0007	36 W - 12 W		MISSING
0008	12 W - 12 E		MISSING
0009	12 E - 36 E		MISSING
0010	36 E - 60 E		MISSING
0011	60 E - 84 E		MISSING
0012	84 E - 108 E		MISSING
0013	108 E - 132 E		MISSING
0014	132 E - 156 E		MISSING
0015	156 E - 180 E		MISSING

ZONE 02 85 S - 80 S

REGION	LONGITUDE	TAPE AREA NAME	CATEGORY
0016	180 W - 156 W		MISSING
0017	156 W - 132 W		MISSING
0018	132 W - 108 W		MISSING
0019	108 W - 84 W		MISSING
0020	84 W - 60 W		MISSING
0021	60 W - 36 W		MISSING
0022	36 W - 12 W		MISSING
0023	12 W - 12 E		MISSING
0024	12 E - 36 E		MISSING
0025	36 E - 60 E		MISSING
0026	60 E - 84 E		MISSING
0027	84 E - 108 E		MISSING
0028	108 E - 132 E		MISSING
0029	132 E - 156 E		MISSING
0030	156 E - 180 E		MISSING

Figure 4-1. (Continued).

65

TOFOG REGION SUMMARY

ZONE 28 45 N - 50 N

REGION	LONGITUDE	TAPE AREA NAME	CATEGORY
2611	180 W - 177 W		MISSING
2612	177 W - 174 W		MISSING
2613	174 W - 171 W		MISSING
2614	171 W - 168 W		MISSING
2615	168 W - 165 W		MISSING
2616	165 W - 162 W		MISSING
2617	162 W - 159 W		MISSING
2618	159 W - 156 W		MISSING
2619	156 W - 153 W		MISSING
2620	153 W - 150 W		MISSING
2621	150 W - 147 W		MISSING
2622	147 W - 144 W		MISSING
2623	144 W - 141 W		OCEAN
2624	141 W - 138 W		OCEAN
2625	138 W - 135 W		OCEAN
2626	135 W - 132 W		OCEAN
2627	132 W - 129 W		OCEAN
2628	129 W - 126 W	VICTORIA	T 2629
2629	126 W - 123 W	VICTORIA	T 2629
2630	123 W - 120 W	SEATTLE	T 2630
2631	120 W - 117 W	SPOKANE	T 2631
2632	117 W - 114 W		MISSING
2633	114 W - 111 W		MISSING
2634	111 W - 108 W		MISSING
2635	108 W - 105 W		MISSING
2636	105 W - 102 W		MISSING
2637	102 W - 99 W		MISSING
2638	99 W - 96 W		MISSING
2639	96 W - 93 W		MISSING
2640	93 W - 90 W		MISSING

Figure 4-1. (Continued).

TOPOG REGION SUMMARY

ZONE 35 80 N - 85 N

REGION	LONGITUDE	TAPE AREA NAME	CATEGORY
3031	180 W - 156 W		MISSING
3032	156 W - 132 W		MISSING
3033	132 W - 108 W		MISSING
3034	108 W - 84 W		MISSING
3035	84 W - 60 W		MISSING
3036	60 W - 36 W		MISSING
3037	36 W - 12 W		MISSING
3038	12 W - 12 E		MISSING
3039	12 E - 36 E		MISSING
3040	36 E - 60 E		MISSING
3041	60 E - 84 E		MISSING
3042	84 E - 108 E		MISSING
3043	108 E - 132 E		MISSING
3044	132 E - 156 E		MISSING
3045	156 E - 180 E		MISSING

ZONE 36 85 N - 90 N

REGION	LONGITUDE	TAPE AREA NAME	CATEGORY
3046	180 W - 156 W		MISSING
3047	156 W - 132 W		MISSING
3048	132 W - 108 W		MISSING
3049	108 W - 84 W		MISSING
3050	84 W - 60 W		MISSING
3051	60 W - 36 W		MISSING
3052	36 W - 12 W		MISSING
3053	12 W - 12 E		MISSING
3054	12 E - 36 E		MISSING
3055	36 E - 60 E		MISSING
3056	60 E - 84 E		MISSING
3057	84 E - 108 E		MISSING
3058	108 E - 132 E		MISSING
3059	132 E - 156 E		MISSING
3060	156 E - 180 E		MISSING

Figure 4-1. (Continued)

(3) ADD card

The keyword ADD is used to instruct FIXDRY to update an existing TOPOG directory file to account for the addition of a terrain elevation file (tape) or an "ocean" region to the TOPOG data base, as described in Section 4.2.1. To add a terrain elevation file, the input data format is

ADD,TAPE,xxxx

where xxxx is the numerical portion of the tape vsn (i.e., the index of the initial (westernmost) region in the tape area). To add an "ocean" region, the input data format is

ADD,OCEAN,xxxx

where xxxx is the index of the region being categorized as ocean.

(4) DELETE card

The keyword DELETE is used to instruct FIXDRY to update an existing TOPOG directory file to account for the deletion of a terrain elevation file (tape) or an "ocean" region from the TOPOG data base, as described in Section 4.2.1. To delete a terrain elevation file, the input data format is

DELETE,TAPE,xxxx

where xxxx is the numerical portion of the tape vsn. In deleting an ocean region, the input data format is

DELETE,OCEAN,xxxx

where xxxx is the index of the region whose category is being changed from "ocean" to "missing". (This action is needed only to correct a previous erroneous change from "missing" to "ocean").

(5) PRINT card

The keyword PRINT is used to direct FIXDRY to print a TOPOG region summary, as described in Section 4.2.1.

4.2.3 Job Control Language

The control card sequence for a FIXDRY run (under NOS) is included in Table 4-1, which shows a sample FIXDRY input data deck. Aside from attaching and executing the program itself, the need for two tape drives must be specified (by the card RESOURC, NT=2.) when adding terrain elevation files

Table 4-1. FIXDRY Input Data Deck for Updating TOPOG Directory File

```
PSJP,T77.
USER,EMCAD.
CHARGE,910,910xxxx.
RESOURC,NT=2.
GET FIXDRY.
FIXDRY.
/EOR    {end-of-record}
TOPOG DIRECTORY UPDATE
ADD,TAPE,2628
DELETE,OCEAN,2629
DELETE,OCEAN,2632
ADD,OCEAN,2626
ADD,OCEAN,2625
ADD,OCEAN,2624
PRINT
/EOF {end-of-file}
```

(tapes) to the TOPOG data base. One of these is for the TOPOG directory file TOPDRY; the other accommodates the TOPOG tapes being added.

4.2.4 Sample FIXDRY Input/Output

Figure 4-1 shows a portion of a FIXDRY run which updated an existing TOPOG directory file by deleting two ocean regions, adding a terrain elevation file (tape) and several ocean regions, and printed a TOPOG region summary. For the sake of brevity, only the title page and two pages of data from the TOPOG region summary are illustrated.

4.3 FIXDRY Internal Software Description

The FIXDRY software consists of a main controlling program (FIXDRY) and a set of subroutines which read and process input data, perform various update procedures on the TOPOG directory file, and print a TOPOG region summary. The structure of the software is shown in Figure 4-2. Files and COMMON blocks used throughout FIXDRY are described in Tables 4-2 and 4-3.

4.3.1 FIXDRY

FIXDRY is the main program of the software for maintaining the TOPOG directory file. It issues the initial message "TOPOG REGION DIRECTORY MAINTENANCE" to the dayfile and calls the system clock to obtain the starting time in seconds. FIXDRY then calls INPUT to read and process the input data cards. If fatal errors are detected by INPUT, FIXDRY will abort the run. Otherwise, FIXDRY creates the file information tables for the files TOPDRY and REGDRY, and opens these files for later use.

FIXDRY then calls REVISE to create an initial version of the TOPOG directory file or to update an existing file. Subsequently, if the error count NERR is not zero, FIXDRY aborts the run; otherwise it checks the PRINT flag. If the PRINT flag has been set by INPUT, FIXDRY calls PRINT to print a TOPOG region summary.

When FIXDRY finishes data processing, regardless of whether the run is good or aborted, it closes the files TOPDRY and REGDRY, then checks the error count NERR. It then either displays the number of errors or issues the

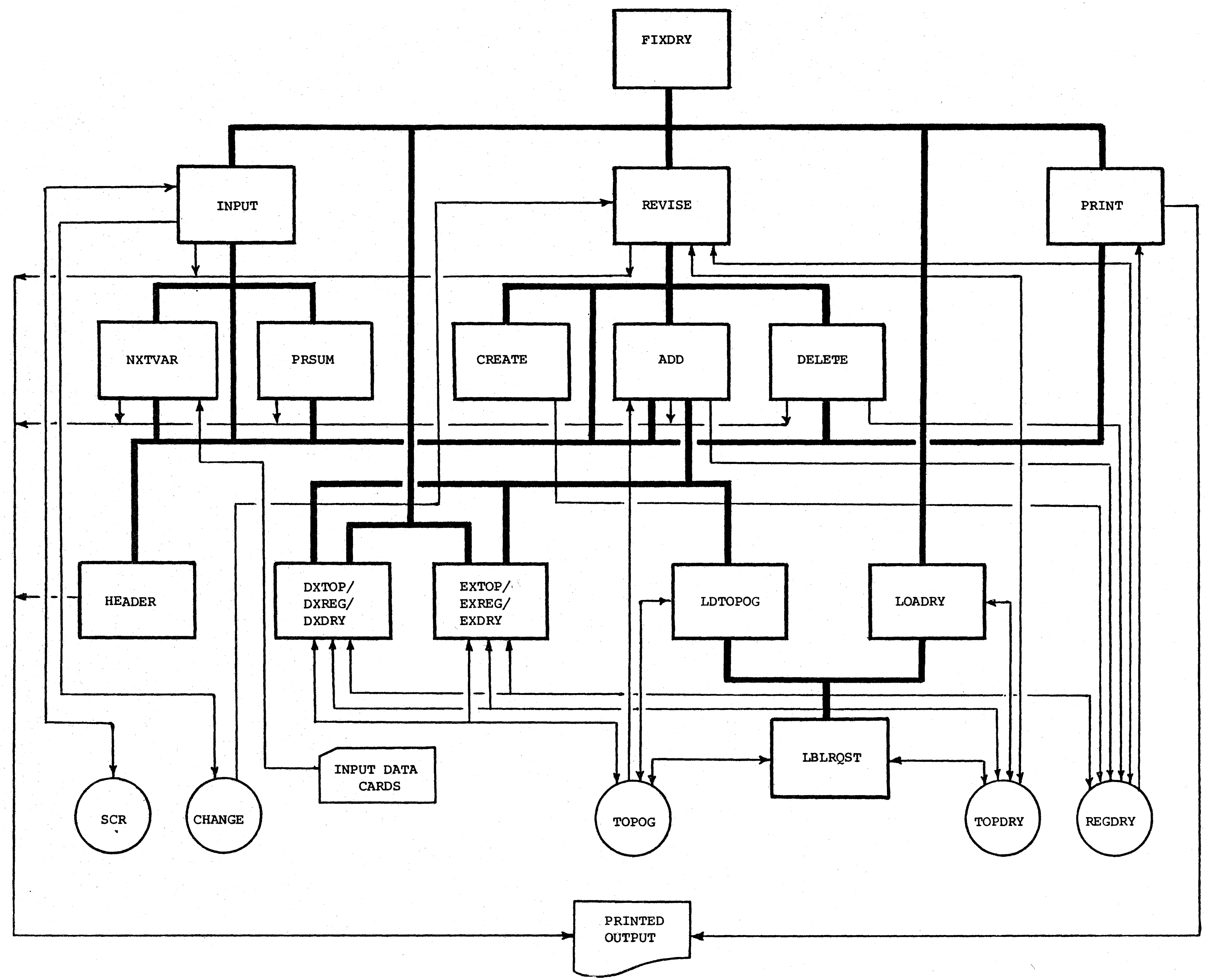


Figure 4-2. FIXDRY program elements and files.

Table 4-2. FIXDRY Files

File Name	Description
TOPDRY	TOPOG directory file (tape version) (see Section 2.3.5)
REGDRY	TOPOG directory file (disk version)
TOPOG	TOPOG terrain elevation file (see Section 2.3.1)
CHANGE	Sequential file containing sorted DELETE/ADD input data
SCR	Sequential scratch file containing unsorted DELETE/ADD input data

Table 4-3. FIXDRY Common Blocks

Common Block /GLOBAL/

ITITLE	Title of current run
IDATE	Current date
ITIME	Current time
ICREAT	Flag for creating initial version of TOPOG directory file (0=no, 1=yes)
IPRINT	Flag for printing TOPOG region summary (0=no, 1=yes)
KODREG	TOPOG region directory array (contains biased category codes)
NERR	Number of fatal errors

Common Block /ZFIT/

IFIT	File Information Table for TOPDRY
IBUFF	Record Manager buffer for TOPDRY
MFIT	File Information Table for REGDRY
MBUFF	Record Manager buffer for REGDRY
NFIT	File Information Table for TOPOG
NBUFF	Record Manager buffer for TOPOG

Common Block /FLAGS/

ISTATUS	Status flag for TOPDRY (0=ok, 1=error, -1=end-of-data)
MSTATUS	Status flag for REGDRY (0=ok, 1=error, -1=end-of-data)
NSTATUS	Status flag for TOPOG (0=ok, 1=error, -1=end-of-file)

message "TOPOG DIRECTORY UPDATED", and displays the execution time in CP seconds in the dayfile.

4.3.2 HEADER

HEADER is called by all routines that print formatted output to control pagination on the output listing. It counts the number of lines that have been printed, and titles new pages as they are needed. It prints two header lines on each page, giving the FIXDRY run title, the date and time of the run, and the page number. HEADER is called with one parameter, NLINES, which specifies the number of lines to be printed in a contiguous group. If this number is greater than the number of lines left on the current page, a page eject will be issued and the header lines printed so that the group of lines will not be split across a page boundary. A new page may be requested by setting NLINES to -1. The local variable MAXL is initialized to allow 60 lines per page.

4.3.3 DXTOP/DXREG/DXDRY

DXTOP is the main entry point to this routine which also contains the entry points DXREG and DXDRY. These are the exit addresses supplied to Record Manager to be used in processing end-of-data conditions on the files TOPOG, REGDRY, and TOPDRY, respectively. The COMMON block /FLAGS/ is used to pass the end-of-data condition to the program reading the file by setting the appropriate file status flag to a value less than zero.

4.3.4 EXTOP/EXREG/EXDRY

EXTOP is the main entry point to this routine which also contains the entry points EXREG and EXDRY. These are the exit addresses supplied to Record Manager to be used in processing error conditions on the files TOPOG, REGDRY, and TOPDRY, respectively. The COMMON block /FLAGS/ is used to pass an error condition to the program reading the file by setting the appropriate file status flag to a value greater than zero.

4.3.5 INPUT

INPUT is called from FIXDRY to read and process input data cards. INPUT first reads the FIXDRY run title card and gets the date and time from the system clock. It then calls NXTVAR to return the next keyword from an input data card, determines the keyword, and branches to the section that processes that keyword. The keyword CREATE is used to set a flag that instructs FIXDRY to generate an "initial version" of the TOPOG directory file; i.e., one in which all TOPOG regions are categorized as "missing" and all tape area names are blank-filled. The keyword ADD is used to instruct REVISE to update an existing TOPOG directory file to account for the addition of a specified terrain elevation file (tape) or "ocean" region to the TOPOG data base. The keyword DELETE serves in the same capacity for deleting one of those entities from the TOPOG data base. Both of these keywords must be followed by TAPE or OCEAN to indicate the type of entity to be added or deleted, and by a region index that specifies the particular entity. INPUT checks this information for syntax errors and valid index range. If valid, INPUT writes the ADD or DELETE data to a scratch file SCR. Finally, the keyword PRINT is used to set a flag that instructs FIXDRY to print a TOPOG region summary. If INPUT detects an error, it updates the error count NERR and prints a diagnostic message.

When all input data cards have been read, INPUT checks the error count NERR. If it is not zero, control returns to FIXDRY. Otherwise, INPUT sorts the ADD and DELETE data stored on file SCR, and writes the sorted data on file CHANGE. The data items in CHANGE are arranged so that all DELETE items precede any ADD item. Within each of these categories, data items are arranged in the order of increasing region index. Finally, when NERR=0, INPUT calls PRSUM to print the input data summary.

4.3.6 NXTVAR

NXTVAR is called from INPUT to crack the free-format input data cards into fields of alphanumeric keywords and floating point numeric values that are returned for processing. Successive cards are read until the end-of-file is encountered. Each card is printed when it is read so that error messages pertaining to that data card will immediately follow the printed card image. On each call to NXTVAR, the next alpha or numeric value along with the following delimiter is returned. If the variable read is not of the type requested (alpha or numeric), an error message will be printed and the error flag will be set. All 80 columns of the data card will be processed. Blanks are ignored. The five characters =,/() are recognized as delimiters. The first non-numeric character following a numeric field is also considered a delimiter. Integer values are returned as floating point numbers. If a syntax error is encountered, the rest of the card is skipped. Input values may not span card boundaries. NXTVAR has one parameter, ITYPE, which gives the type of the field expected (1=keyword, 2=number, 3=delimiter, 4=alpha). The value of the decoded field is returned in the variables IVAR (in A10 format) and XNUM (floating point number or -1.0 in the case of a null field followed by a right parenthesis or a comma. It also returns IDEL (the delimiter found as one of the characters =,/() in A1 format or -1 to signify end-of-card), and IERR (0=ok, 1=error found by NXTVAR, -1=error found by the calling routine, or 99=end-of-file on input file) the error flag. These variables are found in common block /NXTVAR/.

4.3.7 PRSUM

PRSUM is called from INPUT to print a summary of input data used in a FIXDRY run. It calls HEADER to control pagination of the output listing. The FIXDRY input data summary is not printed if errors have been detected in the input data. It is intended to give the user a summary of the data values used in a particular FIXDRY run to update the TOPOG directory file. The information includes the date, time and title of the run, CREATE and PRINT flag values, and the contents of all ADD and DELETE cards. The ADD and DELETE data are printed from information stored in the file CHANGE by INPUT. Remaining input data are printed from information stored in common block /GLOBAL/ by INPUT.

4.3.8 LOADRY

LOADRY is called from REVISE to request the TOPOG directory file (tape) TOPDRY. It stores the volume serial number (vsn) of the tape to be requested and the processing options (9-track, 1600 bpi, I format, PO=RW, and unlabeled) in words 8 and 9 of the FIT. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

4.3.9 LDTOPOG

LDTOPOG is called from ADD to request a specified TOPOG terrain elevation file (tape). It initializes the FIT for file TOPOG, then stores the vsn of the tape to be requested and the processing options (9-track, 1600 bpi, I format, PO=RA, and unlabeled) in words 8 and 9 of the FIT. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

4.3.10 LBLRQST

LBLRQST is a COMPASS routine called from LOADRY to request the directory file and from LDTOPOG to request a specified TOPOG tape. It has one parameter, IFET, which is an array containing the FET for the tape file. Notice that the FIT and FET addresses are the same since the FET is actually the initial part of the FIT. The LABEL (NOS) or REQUEST (NOS/BE) macro is used to make the actual tape request.

4.3.11 REVISE

REVISE is called from FIXDRY to create an initial version of a TOPOG directory file or to update an existing file to account for additions or deletions from a TOPOG data base.

If the CREATE flag has been set by INPUT, REVISE calls the routine CREATE to generate an "initial version" of the TOPOG directory file REGDRY. In this version, all TOPOG regions are categorized as "missing" and all tape area names are blank-filled. Otherwise, REVISE copies an existing TOPOG directory file from TOPDRY (tape) to REGDRY (disk), and stores the region directory in the array KODREG.

REVISE then reads successive "DELETE" or "ADD" input records from the file CHANGE and checks the keyword. These records were written to CHANGE by INPUT, which also sorted them so all "DELETE" records precede any "ADD" record. If the keyword is ADD, REVISE calls the routine ADD to update REGDRY to account for the addition of a specified terrain elevation file (tape) or "ocean" region to the TOPOG data base. Otherwise, if the keyword is DELETE, REVISE calls the routine DELETE to update REGDRY to account for the deletion of one of those entities from the data base. After each call to ADD or DELETE, REVISE checks the error count NERR. If it is not zero, control returns to FIXDRY.

When an end-of-file is detected on reading CHANGE, REVISE copies the updated version of the TOPOG directory file from REGDRY (disk) back to TOPDRY (tape).

4.3.12 CREATE

CREATE is called from REVISE to generate an "initial version" of a TOPOG directory file; i.e., one in which all TOPOG regions are categorized as "missing" and all tape area names are blank-filled. CREATE first sets all entries in the region directory array KODREG to zero. Since this array consists of packed biased region category codes (see Section 2.3.5) K_R^*, and K_R^* is related to the region category code K_R^* by $K_R = K_R + 1$, this action is equivalent to categorizing each region as "missing" (i.e., having $K_R = -1$). CREATE then writes the directory array KODREG to the file REGDRY. It next writes 3060 two-word blank-filled tape area name records to REGDRY.

4.3.13 ADD

ADD is called from REVISE to update an existing TOPOG directory file to account for the addition of a terrain elevation file (tape) or an ocean region to the TOPOG data base. ADD has two parameters, ITYPE and IREG. ITYPE contains a character string identifying the type of entity being added. The string is TAPE if a terrain elevation file is being added, and OCEAN if an ocean region is being added. IREG is the numerical portion of the tape vsn when a terrain elevation file is added, and the (global) region index when an ocean region is added.

ADD first extracts the category code K_R of region IREG from the TOPOG region directory (which is stored in the array KODREG), and checks to see if $K_R = -1$ (i.e., if the region is "missing"). If not, ADD updates the error count NREG, prints a diagnostic message, and returns to REVISE. Otherwise, ADD checks ITYPE.

If ITYPE=OCEAN, ADD simply revises the region directory by changing the category code of the affected region from -1 (missing) to 0 (ocean). If ITYPE=TAPE, ADD creates the TOPOG tape FIT with a FILESQ call, encodes the tape vsn, and loads the specified TOPOG tape with a call to the routine LDTOPOG. It then opens the TOPOG tape file and reads in the preface record from the tape, and closes the file. ADD extracts the tape area name and number N_R of regions in the tape area from the preface record. If $N_R>1$, it checks remaining regions to see if they are also categorized as "missing". If not, ADD updates the error count NERR, prints a diagnostic message, and returns control to REVISE. Otherwise, it revises the region directory by making K_R=IREG for each region in the TOPOG tape area. Finally, ADD writes the tape area name to REGDRY for each relevant region.

4.3.14 DELETE

DELETE is called from REVISE to update an existing TOPOG directory file to account for the deletion of a terrain elevation file (tape) or an ocean region from the TOPOG data base. DELETE has two parameters, ITYPE and IREG. ITYPE contains a character string identifying the type of entity being deleted. If a terrain elevation file (tape) is being deleted, the string is TAPE; if an ocean region is being deleted, the string is OCEAN. IREG is the numerical portion of the tape vsn when a terrain elevation file is being deleted. When an ocean region is being deleted, IREG is the (global) index of that region.

DELETE first extracts the category code K_R of region IREG from the TOPOG region directory (which is stored in the array KODREG). If ITYPE=OCEAN, DELETE checks to see if $K_R=0$. If so, it replaces this with -1, packs the new biased category code $K_R^*=K_R+1=0$ back into the region directory, and returns control to FIXDRY. Otherwise (if $K_R\neq0$), DELETE updates the error count NERR, prints a diagnostic message, and returns control to REVISE.

If ITYPE=TAPE, DELETE checks to see if K_R=IREG (category code=region index is a condition characterizing the initial (westernmost) region of every TOPOG tape area). If not, it updates the error count NERR, prints a diagnostic message, and returns control to REVISE. Otherwise, DELETE examines subsequent entries in the region directory until a different K_R-value is encountered; this defines the number N_R of regions in the relevant tape area. DELETE then revises the region directory, categorizing the affected regions as "missing". In REGDRY, it replaces the relevant tape area name(s) with blanks.

4.3.15 PRINT

PRINT is called from FIXDRY to print the TOPOG region summary. After writing a title page, PRINT initializes the TOPOG region index and enters a DO-loop on the TOPOG zone index. It evaluates zone boundary coordinates and the number of TOPOG regions in the zone, then enters a DO-loop on the sequence numbers of regions in that zone. Within this loop, PRINT updates the TOPOG (global) region index and calculates boundary longitudes for the region. It then checks for page eject (information for 30 TOPOG regions is printed on each page of the summary), and when required, prints zone data and column headings. PRINT then reads the tape area name from the TOPOG directory file REGDRY and defines the region category. It then prints the region information on a line in the summary.

5. TOPOG TERRAIN ELEVATION FILE GENERATION: PROGRAM GENTOP

5.1 Introduction

Program GENTOP generates the TOPOG terrain elevation files from the data obtained from the Defense Mapping Agency. Currently, DMA has digitized terrain elevation data for over half of the continental United States. When completed, the TOPOG data base will contain terrain elevation data for 3060 TOPOG regions covering the entire world. The TOPOG tapes may be generated for the data base in any order. A tape may be regenerated if it originally contained missing data points and those data later become available. The structure of the DMA tapes is described in Section 5.2.2 and the TOPOG tapes are documented in Section 2.

5.2 User's Guide to GENTOP

5.2.1 Overview

A relatively small amount of informaton is required from the user to generate a terrain elevation file for the TOPOG data base. The input data define the latitude and longitude of the southwest corner of the TOPOG tape area, the number of regions included in the tape area, and the volume serial number of the TOPOG output tape. It also specifies whether this is the initial generation of the tape for this area or a replacement tape so that the

4.3.15 PRINT

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A relatively small amount of informaton is required from the user to generate a terrain elevation file for the TOPOG data base. The input data define the latitude and longitude of the southwest corner of the TOPOG tape area, the number of regions included in the tape area, and the volume serial number of the TOPOG output tape. It also specifies whether this is the initial generation of the tape for this area or a replacement tape so that the region directory can be properly updated. The input data also describe the number of "source areas" per row, the number of "source blocks" in each source area, and the "category code" or volume serial number and file number of the DMA source tape containing the terrain elevation data for each "source area". Certain ocean blocks to be included in the TOPOG tape area may also be specified in the input data. The input data are described in detail in Section 5.2.3.

GENTOP processes the free-format user input data, prints any relevant error messages, and, if the data are correct, prints the TOPOG Input Data Summary to give the user a record of the data used to generate the TOPOG tape. The user does not need to request the DMA source tapes or the TOPOG output tape because they are automatically requested by GENTOP as they are needed. The user must, however, specify in the control cards that two 9-track tapes will be used so that the job will not exceed the resource limit. GENTOP prints a summary of the data present on the TOPOG output tape. This information includes the name and volume serial number of the tape, the latitude and longitude of the boundaries of the regions covered, the date, the organization creating the tape, and the grid intervals for the terrain elevation data. It also prints a block status map showing the status (complete, partial, ocean, or missing) of the data for each block in each region included in the tape area. Section 5.2.5 shows samples of GENTOP input/output for the generation of three TOPOG tapes.

5.2.2 Source (DMA) Data Structure

The source terrain elevation data are obtained on magnetic tape from the Defense Mapping Agency. These tapes conform to the DMA Standard for Digital Terrain Elevation Files which is described in the Appendix. They are 2400-foot reels of 1/2-inch magnetic tape recorded on a UNIVAC system as 9-track, 1600-bpi density, odd parity with ANSI labels, and binary, unblocked, fixed-length data records. However, because some fields in the ANSI labels are incorrectly specified or omitted, the DMA tapes cannot be read as ANSI standard labeled tapes. Specifically, the file sequence numbers are all set to 1, so it is impossible to position properly the multi-file set to the desired data file. Also, the block counts have not been entered in the trailer labels. Consequently, the tapes must be requested as unlabeled (NOS) or nonstandard labeled (NOS/BE) stranger tapes and the labels read and processed by the program rather than the system.

Each tape consists of a set of files corresponding to 1° x 1° sequential areas organized into west-to-east order. The latitude and longitude of the southwest corner of each 1° x 1° area is given in the user header label for the corresponding file together with the interval spacing for the data points in that file. Each data value is recorded as a true elevation to the nearest meter and stored as a 16-bit signed, binary integer with the sign in the high order position. Blank data values are represented by all 1's. The data values are evenly spaced in latitude and longitude according to the interval spacing chosen for that block and are recorded in south-north/west-east column major order. A detailed description of the contents of the labels and records of the DMA tapes is given in the Appendix.

5.2.3 GENTOP Input Data

5.2.3.1 Input Data Preparation

From the user's point of view, the most demanding task in generating a TOPOG terrain elevation file is probably that of preparing input data to GENTOP. In this section, we describe the input data preparation as a series of steps; Section 5.2.3.2 contains a description of input data cards. A suitable map of the relevant area, to which TOPOG region boundaries and indexes have been added, is generally helpful and sometimes necessary in the preparation of GENTOP input data. Particularly useful in this regard are the Global Navigation charts (GNC), a set of 26 overlapping 1:5,000,000 scale maps that collectively cover the entire world. Prepared by the Defense Mapping Agency and distributed to the public by the National Ocean Survey (NOS) of the U.S. Department of Commerce, these maps have a basic 1° grid, which makes them especially well suited for showing TOPOG regions and preparing GENTOP input. The necessary information for adding region boundaries is contained in Section 2.2.2, but an easier approach is to use the data contained in the TOPOG Region Summary, printed by program FIXDRY.

Step 1: Define TOPOG Tape Area. In the typical case, where the tape area consists of a single region, this is a routine matter of identifying the relevant region. In the case of multi-region tape areas, the definition may sometimes be complicated by the fact that is is not clear whether the limit of 1100 non-ocean blocks will be exceeded. In such instances, it may be necessary to resolve the issue by drawing block boundaries on sufficiently detailed maps, then counting the number of ocean (or non-ocean) blocks in the proposed tape area. The 1:1,000,000 scale Operational Navigation Charts (ONC), also prepared by DMA and distributed by NOS, are convenient and usually adequate for this purpose. In any case, the tape area parameters required for GENTOP input consist of the south boundary latitude ϕ_T^S, the west boundary longitude λ_T^W, the number N_R of regions in the tape area, and the (global) index of the first (westernmost) region in the tape.

Step 2: Identify DMA tapes. We assume the GENTOP user has on hand a set of DMA tapes containing terrain elevation data for the TOPOG tape area defined in Step 1. The structure of the DMA source data is described in detail in Section 5.2.2 and in the Appendix. Here we reiterate the basic notions that each DMA tape contains a sequence of terrain elevation data files, that the geographical counterpart of each such file is a 1° x 1° "block" (called a source block in TOPOG jargon), and that these files are ordered on the DMA tape so that the corresponding 1° x 1° source blocks form a west-to-east sequence. For each DMA tape used in generating a particular TOPOG file, the GENTOP user must know the vsn of that tape and the geographical location of the 1° x 1° source block corresponding to each file on the tape.

Step 3: Categorize source blocks. For this step, the GENTOP user needs a map or diagram of the TOPOG tape area showing all 1° x 1° source blocks. (In middle latitudes, $50°S<\phi<50°N$, note that a source block is equivalent to a TOPOG district.) In each source block in the tape area, the user records exactly one of the following items of information: (i) if the source block corresponds to a file on a DMA source tape, enter the vsn of the DMA tape and the sequence number of the file; (ii) if the source block does not correspond to any file on a DMA tape, enter 0 when the source block is entirely ocean, and -1 when it is not. A sample diagram for TOPOG tape area 2628 (Victoria) is shown in Figure 5-1(a); it contains two regions.

Step 4: Define source areas. A source area consists of a single source block or a west-to-east sequence of adjacent source blocks. Each source block in a TOPOG tape area is incorporated in a source area according to the

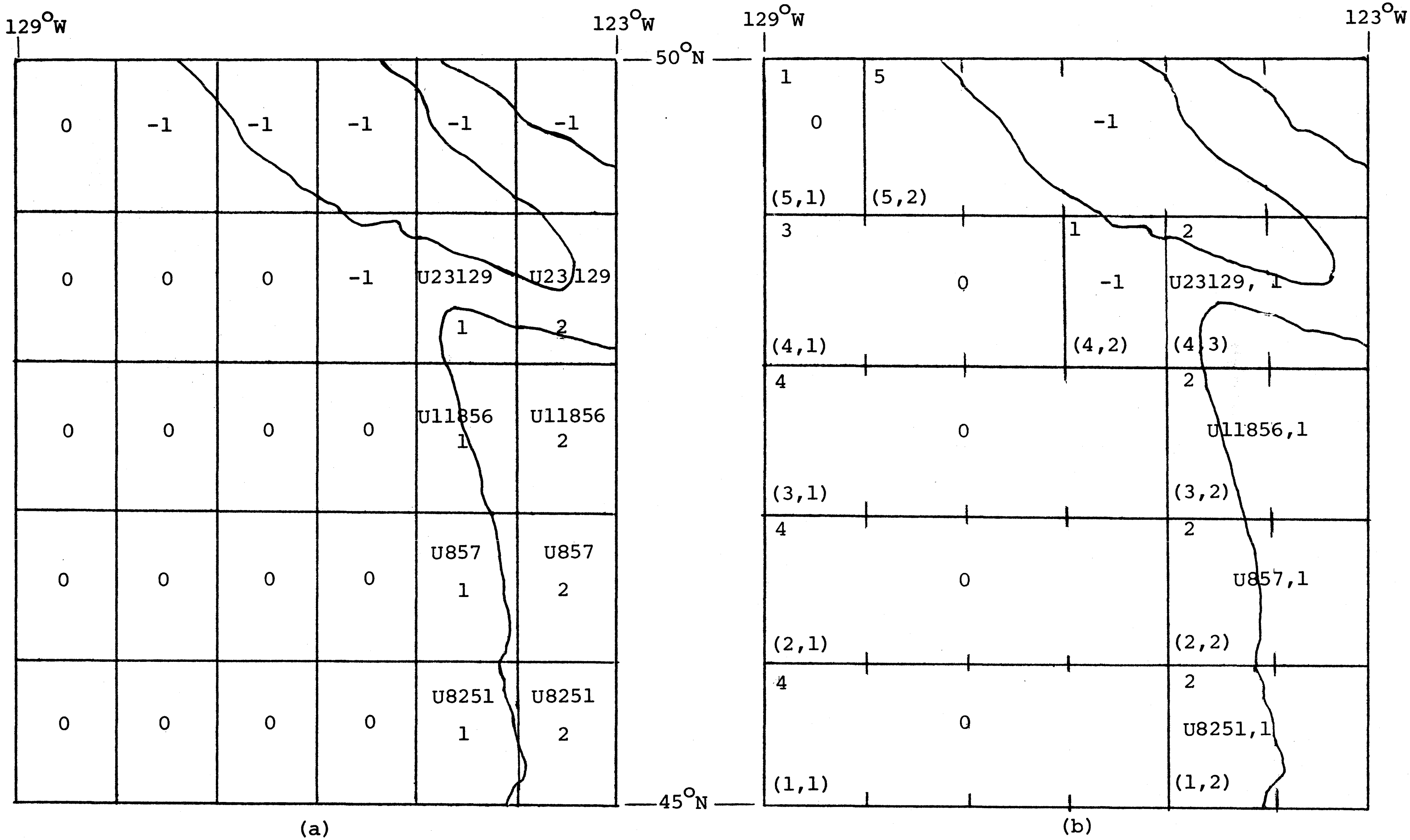

Figure 5-1. TOPOG tape area 2628 (Victoria) showing (a) source blocks and (b) source areas. Source area information in (b) includes number of source blocks in source area (upper left), category code (center), and identifying indexes (lower left).

following rules: (i) a sequence of adjacent source blocks corresponding to successive files on a DMA tape form a "standard" source area; (ii) a sequence of adjacent source blocks each characterized by the number 0 in Step 3 form an "ocean" source area; (iii) a sequence of adjacent source blocks each characterized by the number -1 in Step 3 form a "missing" source area. Each source area is then assigned a source area category code: the codes for ocean and missing source areas are (as one would expect) 0 and -1, respectively, while the code for a standard source area consists of the vsn of the DMA tape followed by the file sequence number corresponding to the first (westernmost) source block in the source area.

A diagram showing all source areas in the TOPOG tape area should now be drawn. To identify these source areas in a precise way, we first regard them as being arranged in five rows, indexed sequentially from south to north. Within a given row, the source areas are indexed sequentially from west to east. A particular source area is then identified by specifying (in order) its row index and its sequence number within that row.

The source area structure of a TOPOG tape area is then completely defined for GENTOP by the following items of information: (i) for each row of source areas--the number of source areas in that row; (ii) for each source area--the row index, the sequence number within the row, the number of source blocks in the source area, and the source area category code. Figure 5-1(b) shows the source areas in TOPOG tape area 2628 with essential GENTOP input data written in each source area.

Step 5 (optional): Define ocean blocks in missing source areas. A source area categorized as missing may in fact contain TOPOG blocks that are entirely ocean (i.e., at zero elevation). GENTOP allows the user the option of specifying such blocks on input, so that they will be categorized as "ocean" rather than "missing" in the appropriate block directory records in the TOPOG file. These blocks may be identified by specifying the latitude and longitude of the southwest corner of each block, as described in Section 5.2.3.2. A sufficiently detailed map, as discussed in Step 1, will be needed to assist in the identification.

5.2.3.2 Input Data Cards

The following input data items are required for a GENTOP run. Each item is entered on a separate card. Blanks are ignored. The data items may be entered in any order except the Title which must be the first card.

(1) Title card

The first card in the input deck is assumed to be the title card. Up to 80 characters of information may be entered. The title is printed on every page of output along with the date and time to identify the job uniquely.

(2) TLATS

The keyword TLATS is used to enter the latitude of the southwest corner of the TOPOG tape area. The format is TLATS = (dd,D) where dd is the latitude in positive degrees within the range of 0 to 90 and D is the direction code N or S.

(3) TLONW

The keyword TLONW is used to enter the longitude of the southwest corner of the TOPOG tape area. The format is TLONW = (ddd,D) where ddd is the longitude in positive degrees within the range of 0 to 180 and D is the direction code E or W.

(4) NREG

The keyword NREG is used to enter the number of regions in the TOPOG tape area. The format is NREG = number of regions. NREG must not exceed 5.

(5) TVSN

The keyword TVSN is used to enter the volume serial number of the TOPOG output tape, the tape status and the name of the tape area. The format is TVSN = (vsn, status code, name) where the vsn for the tape is TGxxxx (xxxx=global region index of the first region in the tape area), the status code is NEW or REPLACE depending on whether or not a tape for this area is already in the data base, and name is a string of up to 20 characters. When REPLACE is entered, the specified TOPOG tape area must exactly match that of the terrain elevation file currently in the data base.

(6) NSA

The keyword NSA is used to enter the number of source areas contained in each row of source areas in the TOPOG tape area. The format is NSA(row no.) = number of source areas.

(7) SORCE

The keyword SORCE is used to enter the number of source blocks and the category code for each source area in the TOPOG tape area. The format is SORCE(row no., source area no.) = (no. of source blocks, category code) for ocean and missing source areas. For standard source areas the format is SORCE(row no., source area no.) = (no. of source blocks, vsn of DMA tape, initial file sequence no.).

The following input data are optional:

(8) OCEAN

The keyword OCEAN is used to specify TOPOG blocks that are to be categorized in the data base as ocean when such blocks are contained in a missing source area. The blocks may be arranged in any order. The format is OCEAN = (dd,mm,ss,D1/ddd,mm,ss,D2) which gives the latitude and longitude of the ocean TOPOG block in positive degrees, minutes, seconds with a direction code. The latitude is given first and must be within the range 0 to 90. The legal direction codes for D1 are N and S. The longitude is separated from the latitude by a slash and must be within the range 0 to 180. The legal direction codes for D2 are E and W.

5.2.4 Job Control Language

The control card sequence required to run GENTOP is fairly simple. Aside from attaching and executing the program itself, the need for two tape drives must be specified. One of these is for the TOPOG directory file TOPDRY; the other accommodates the DMA source tapes (file SOURCE) and the generated TOPOG tape (file TOPOG). Tables 5-1 through 5-3 show the input decks for the generation of our three sample TOPOG tapes - TG2628, TG2630, and TG2631 under

Table 5-1. GENTOP Input Data Deck for Generating TOPOG Tape TG2628

```
TOPO,T1777.
USER(EMCAD)
CHARGE,910,910xxxx.
ATTACH,GENTOP.
RESOURC,NT=2.
GENTOP(PL=10000)
DAYFILE(TG2628D)
REPLACE(TG2628D)
EXIT.
DEFINE,RESTRT.
REWIND,STOREC.
COPYEI,STOREC,RESTRT.
/EOR     {end-of-record}
TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)
TLATS=(45,N)
TLONW=(129,W)
NREG=2
TVSN=(TG2628,NEW)
NSA(1)=2
NSA(2)=2
NSA(3)=2
NSA(4)=3
NSA(5)=2
SORCE(1,1)=(4,0)
SORCE(1,2)=(2,U8251,1)
SORCE(2,1)=(4,0)
SORCE(2,2)=(2,U857,1)
SORCE(3,1)=(4,0)
SORCE(3,2)=(2,U11856,1)
SORCE(4,1)=(3,0)
```

Table 5-1. (Continued)

```
SORCE(4,2)=(1,-1)
SORCE(4,3)=(2,U23129,1)
SORCE(5,1)=(1,0)
SORCE(5,2)=(5,-1)
OCEAN=(48,00,00,N/126,00,00,W)
OCEAN=(48,07,30,N/126,00,00,W)
OCEAN=(48,15,00,N/126,00,00,W)
OCEAN=(48,22,30,N/126,00,00,W)
OCEAN=(48,30,00,N/126,00,00,W)
OCEAN=(48,37,30,N/126,00,00,W)
OCEAN=(48,45,00,N/126,00,00,W)
OCEAN=(48,52,30,N/126,00,00,W)
OCEAN=(48,00,00,N/125,52,30,W)
OCEAN=(48,07,30,N/125,52,30,W)
OCEAN=(48,15,00,N/125,52,30,W)
OCEAN=(48,22,30,N/125,52,30,W)
OCEAN=(48,30,00,N/125,52,30,W)
OCEAN=(48,37,30,N/125,52,30,W)
OCEAN=(48,45,00,N/125,52,30,W)
OCEAN=(48,52,30,N/125,52,30,W)
OCEAN=(48,00,00,N/125,45,00,W)
OCEAN=(48,07,30,N/125,45,00,W)
OCEAN=(48,15,00,N/125,45,00,W)
OCEAN=(48,22,30,N/125,45,00,W)
OCEAN=(48,30,00,N/125,45,00,W)
OCEAN=(48,37,30,N/125,45,00,W)
OCEAN=(48,45,00,N/125,45,00,W)
OCEAN=(48,00,00,N/125,45,00,W)
OCEAN=(48,00,00,N/125,37,30,W)
OCEAN=(48,07,30,N/125,37,30,W)
OCEAN=(48,15,00,N/125,37,30,W)
OCEAN=(48,22,30,N/125,37,30,W)
OCEAN=(48,30,00,N/125,37,30,W)
```

Table 5-1. (Continued)

```
OCEAN=(48,37,30,N/125,37,30,W)
OCEAN=(48,45,00,N/125,37,30,W)
OCEAN=(48,00,00,N/125,30,00,W)
OCEAN=(48,07,30,N/125,30,00,W)
OCEAN=(48,15,00,N/125,30,00,W)
OCEAN=(48,22,30,N/125,30,00,W)
OCEAN=(48,30,00,N/125,30,00,W)
OCEAN=(48,37,30,N/125,30,00,W)
OCEAN=(48,45,00,N/125,30,00,W)
OCEAN=(48,00,00,N/125,22,30,W)
OCEAN=(48,07,30,N/125,22,30,W)
OCEAN=(48,15,00,N/125,22,30,W)
OCEAN=(48,22,30,N/125,22,30,W)
OCEAN=(48,30,00,N/125,22,30,W)
OCEAN=(48,37,30,N/125,22,30,W)
OCEAN=(48,00,00,N/125,15,00,W)
OCEAN=(48,07,30,N/125,15,00,W)
OCEAN=(48,15,00,N/125,15,00,W)
OCEAN=(48,22,30,N/125,15,00,W)
OCEAN=(48,30,00,N/125,15,00,W)
OCEAN=(48,00,00,N/125,07,30,W)
OCEAN=(48,07,30,N/125,07,30,W)
OCEAN=(48,15,00,N/125,07,30,W)
OCEAN=(48,22,30,N/125,07,30,W)
OCEAN=(48,30,00,N/125,07,30,W)
OCEAN=(49,00,00,N/128,00,00,W)
OCEAN=(49,07,30,N/128,00,00,W)
OCEAN=(49,15,00,N/128,00,00,W)
OCEAN=(49,22,30,N/128,00,00,W)
OCEAN=(49,30,00,N/128,00,00,W)
OCEAN=(49,37,30,N/128,00,00,W)
OCEAN=(49,45,00,N/128,00,00,W)
```

Table 5-1. (Continued)

```
OCEAN=(49,52,30,N/128,00,00,W)
OCEAN=(49,00,00,N/127,52,30,W)
OCEAN=(49,07,30,N/127,52,30,W)
OCEAN=(49,15,00,N/127,52,30,W)
OCEAN=(49,22,30,N/127,52,30,W)
OCEAN=(49,30,00,N/127,52,30,W)
OCEAN=(49,37,30,N/127,52,30,W)
OCEAN=(49,45,00,N/127,52,30,W)
OCEAN=(49,52,30,N/127,52,30,W)
OCEAN=(49,00,00,N/127,45,00,W)
OCEAN=(49,07,30,N/127,45,00,W)
OCEAN=(49,15,00,N/127,45,00,W)
OCEAN=(49,22,30,N/127,45,00,W)
OCEAN=(49,30,00,N/127,45,00,W)
OCEAN=(49,37,30,N/127,45,00,W)
OCEAN=(49,45,00,N/127,45,00,W)
OCEAN=(49,52,30,N/127,45,00,W)
OCEAN=(49,00,00,N/127,37,30,W)
OCEAN=(49,07,30,N/127,37,30,W)
OCEAN=(49,15,00,N/127,37,30,W)
OCEAN=(49,22,30,N/127,37,30,W)
OCEAN=(49,30,00,N/127,37,30,W)
OCEAN=(49,37,30,N/127,37,30,W)
OCEAN=(49,45,00,N/127,37,30,W)
OCEAN=(49,00,00,N/127,30,00,W)
OCEAN=(49,07,30,N/127,30,00,W)
OCEAN=(49,15,00,N/127,30,00,W)
OCEAN=(49,22,30,N/127,30,00,W)
OCEAN=(49,30,00,N/127,30,00,W)
OCEAN=(49,37,30,N/127,30,00,W)
OCEAN=(49,45,00,N/127,30,00,W)
OCEAN=(49,00,00,N/127,22,30,W)
```

Table 5-1. (Continued)

```
OCEAN=(49,07,30,N/127,22,30,W)
OCEAN=(49,15,00,N/127,22,30,W)
OCEAN=(49,22,30,N/127,22,30,W)
OCEAN=(49,30,00,N/127,22,30,W)
OCEAN=(49,37,30,N/127,22,30,W)
OCEAN=(49,45,00,N/127,22,30,W)
OCEAN=(49,00,00,N/127,15,00,W)
OCEAN=(49,07,30,N/127,15,00,W)
OCEAN=(49,15,00,N/127,15,00,W)
OCEAN=(49,22,30,N/127,15,00,W)
OCEAN=(49,30,00,N/127,15,00,W)
OCEAN=(49,37,30,N/127,15,00,W)
OCEAN=(49,00,00,N/127,07,30,W)
OCEAN=(49,07,30,N/127,07,30,W)
OCEAN=(49,15,00,N/127,07,30,W)
OCEAN=(49,22,30,N/127,07,30,W)
OCEAN=(49,30,00,N/127,07,30,W)
OCEAN=(49,37,30,N/127,07,30,W)
OCEAN=(49,00,00,N/127,00,00,W)
OCEAN=(49,07,30,N/127,00,00,W)
OCEAN=(49,15,00,N/127,00,00,W)
OCEAN=(49,22,30,N/127,00,00,W)
OCEAN=(49,30,00,N/127,00,00,W)
OCEAN=(49,00,00,N/126,52,30,W)
OCEAN=(49,07,30,N/126,52,30,W)
OCEAN=(49,15,00,N/126,52,30,W)
OCEAN=(49,22,30,N/126,52,30,W)
OCEAN=(49,00,00,N/126,45,00,W)
OCEAN=(49,07,30,N/126,45,00,W)
OCEAN=(49,15,00,N/126,45,00,W)
OCEAN=(49,22,30,N/126,45,00,W)
OCEAN=(49,00,00,N/126,37,30,W)
```

Table 5-1. (Continued)

```
OCEAN=(49,07,30,N/126,37,30,W)
OCEAN=(49,00,00,N/126,30,00,W)
OCEAN=(49,07,30,N/126,30,00,W)
OCEAN=(49,00,00,N/126,22,30,W)
OCEAN=(49,07,30,N/126,22,30,W)
OCEAN=(49,00,00,N/126,15,00,W)
OCEAN=(49,07,30,N/126,15,00,W)
OCEAN=(49,00,00,N/126,07,30,W)
OCEAN=(49,45,00,N/126,52,30,W)
OCEAN=(49,15,00,N/124,00,00,W)
OCEAN=(49,15,00,N/123,52,30,W)
OCEAN=(49,15,00,N/123,45,00,W)
OCEAN=(49,07,30,N/123,37,30,W)
OCEAN=(49,15,00,N/123,37,30,W)
OCEAN=(49,00,00,N/123,30,00,W)
OCEAN=(49,07,30,N/123,30,00,W)
OCEAN=(49,00,00,N/123,22,30,W)
/EOF   {end-of-file}
```

Table 5-2. GENTOP Input Data Deck for Generating TOPOG Tape TG2630

```
TOPO,T1777.
USER(EMCAD)
CHARGE,910,910xxxx.
ATTACH,GENTOP.
RESOURC,NT=2.
GENTOP(PL=10000)
DAYFILE(TG2630D)
REPLACE(TG2630D)
EXIT.
DEFINE,RESTRT.
REWIND,STOREC.
COPYEI,STOREC,RESTRT.
/EOR   {end-of-record}
TOPOG FILE  TG2630 - SEATTLE  (USA,CANADA)
TLATS=(45,N)
TLONW=(123,W)
NREG=1
TVSN=(TG2630,NEW)
NSA(1)=1
NSA(2)=1
NSA(3)=1
NSA(4)=1
NSA(5)=1
SORCE(1,1)=(3,U8251,3)
SORCE(2,1)=(3,U857,3)
SORCE(3,1)=(3,U11856,3)
SORCE(4,1)=(3,U23129,3)
SORCE(5,1)=(3,-1)
/EOF   {end-of-file}
```

Table 5-3. GENTOP Input Data Deck for Generating TOPOG Tape TG2631

```
TOPO,T1777.
USER(EMCAD)
CHARGE,910,910xxxx.
ATTACH,GENTOP.
RESOURC,NT=2.
GENTOP(PL=10000)
DAYFILE(TG2631D)
REPLACE(TG2631D)
EXIT.
DEFINE,RESTRT.
REWIND,STOREC.
COPYEI,STOREC,RESTRT.
/EOR    {end-of-record}
TOPOG FILE  TG2631 - SPOKANE  (USA,CANADA)
TLATS=(45,N)
TLONW=(120,W)
NREG=1
TVSN=(TG2631,REPLACE)
NSA(1)=1
NSA(2)=1
NSA(3)=1
NSA(4)=1
NSA(5)=1
SORCE(1,1)=(3,U8251,6)
SORCE(2,1)=(3,U857,6)
SORCE(3,1)=(3,U11856,6)
SORCE(4,1)=(3,U23129,6)
SORCE(5,1)=(3,-1)
/EOF    {end-of-file}
```

a NOS operating system. The corresponding output is shown in Figures 5-2 through 5-4. Notice the dayfiles for these jobs. They show the DMA source tapes being assigned to the file SOURCE as the data are processed, and finally the TOPOG tape being requested to contain the formatted output data.

5.2.5 Sample GENTOP Input/Output

Three sample TOPOG tapes have been generated and are used in the examples in this report. Figures 5-2 through 5-4 show the output listings for these GENTOP runs. The first TOPOG tape is TG2628 which contains data for the Victoria tape area with southwest corner at 45°N and 129°W. It contains two TOPOG regions, numbers 2628 and 2629. The input data show that row 1 of the TOPOG tape area contains two source areas, one ocean and one with data on DMA tape U8251 starting with file 1. Row 2 also contains two source areas. The first is ocean and the second has data on DMA tape U857 starting with file 1. Row 4 has three source areas. The first is ocean, the second is missing, and the third has data on DMA tape U23129. Row 5 has two source areas, the first ocean and the second missing. In missing source areas, ocean blocks have been specified in the input data for TOPOG blocks that otherwise would be categorized as missing. Figure 5-2 also shows the block status map GENTOP prints for the TOPOG tape area. The status of each block, (complete, partial, ocean, or missing) is printed in the map. Notice the ocean and complete blocks corresponding to the coastline area. Figure 5-3 shows the generation of TOPOG tape TG2630, and Figure 5-4 shows the output for the generation of TG2631.

5.3 GENTOP Internal Software Description

The GENTOP software is divided into four overlays consisting of GENTOP - the controlling main overlay; INPUT - which reads and processes data cards; PROCESS - which converts topographic data from the DMA standard format into the TOPOG format; and OUTPUT - which generates the TOPOG tapes and prints summary information. The structure of the overlays is shown in Figures 5-5 through 5-9. Files, common blocks, and important variables used throughout GENTOP are described in Tables 5-4 through 5-6.

The main (0,0) overlay includes the program GENTOP and subroutines TRECOVR, HEADER, LOADRY, LBLRQST, DXSRC/DXREG, and EXSRC/EXREG. It controls

```
TOPOG TERRAIN DATA BASE GENERATION                                        80/05/20.   16.01.14.       PAGE    1
TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)

                    TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)

                    TLATS=(45,N)

                    TLONW=(129,W)

                    NREG=2

                    TVSN=(TG2628,NEW,VICTORIA)

                    NSA(1)=2

                    NSA(2)=2

                    NSA(3)=2

                    NSA(4)=3

                    NSA(5)=2

                    SORCE(1,1)=(4,0)

                    SORCE(1,2)=(2,U8251,1)

                    SORCE(2,1)=(4,0)

                    SORCE(2,2)=(2,U857,1)

                    SORCE(3,1)=(4,0)

                    SORCE(3,2)=(2,U11856,1)

                    SORCE(4,1)=(3,0)

                    SORCE(4,2)=(1,-1)

                    SORCE(4,3)=(2,U23129,1)

                    SORCE(5,1)=(1,0)

                    SORCE(5,2)=(5,-1)

                    OCEAN=(48,00,00,N/126,00,00,W)

                    OCEAN=(48,07,30,N/126,00,00,W)

                    OCEAN=(48,15,00,N/126,00,00,W)

                    OCEAN=(48,22,30,N/126,00,00,W)

                    OCEAN=(48,30,00,N/126,00,00,W)

                    OCEAN=(48,37,30,N/126,00,00,W)

                    OCEAN=(48,45,00,N/126,00,00,W)
```

Figure 5-2. GENTOP output for generation of TOPOG file TG2628 - Victoria (USA,CANADA).

```
OCEAN=(48,52,30,N/126,00,00,W)
OCEAN=(48,00,00,N/125,52,30,W)
OCEAN=(48,07,30,N/125,52,30,W)
OCEAN=(48,15,00,N/125,52,30,W)
OCEAN=(48,22,30,N/125,52,30,W)
OCEAN=(48,30,00,N/125,52,30,W)
OCEAN=(48,37,30,N/125,52,30,W)
OCEAN=(48,45,00,N/125,52,30,W)
OCEAN=(48,52,30,N/125,52,30,W)
OCEAN=(48,00,00,N/125,45,00,W)
OCEAN=(48,07,30,N/125,45,00,W)
OCEAN=(48,15,00,N/125,45,00,W)
OCEAN=(48,22,30,N/125,45,00,W)
OCEAN=(48,30,00,N/125,45,00,W)
OCEAN=(48,37,30,N/125,45,00,W)
OCEAN=(48,45,00,N/125,45,00,W)
OCEAN=(48,00,00,N/125,37,30,W)
OCEAN=(48,07,30,N/125,37,30,W)
OCEAN=(48,15,00,N/125,37,30,W)
OCEAN=(48,22,30,N/125,37,30,W)
OCEAN=(48,30,00,N/125,37,30,W)
OCEAN=(48,37,30,N/125,37,30,W)
OCEAN=(48,45,00,N/125,37,30,W)
OCEAN=(48,00,00,N/125,30,00,W)
OCEAN=(48,07,30,N/125,30,00,W)
OCEAN=(48,15,00,N/125,30,00,W)
OCEAN=(48,22,30,N/125,30,00,W)
OCEAN=(48,30,00,N/125,30,00,W)
```

Figure 5-2. (Continued).

```
OCEAN=(48,37,30,N/125,30,00,W)
OCEAN=(48,45,00,N/125,30,00,W)
OCEAN=(48,00,00,N/125,22,30,W)
OCEAN=(48,07,30,N/125,22,30,W)
OCEAN=(48,15,00,N/125,22,30,W)
OCEAN=(48,22,30,N/125,22,30,W)
OCEAN=(48,30,00,N/125,22,30,W)
OCEAN=(48,37,30,N/125,22,30,W)
OCEAN=(48,00,00,N/125,15,00,W)
OCEAN=(48,07,30,N/125,15,00,W)
OCEAN=(48,15,00,N/125,15,00,W)
OCEAN=(48,22,30,N/125,15,00,W)
OCEAN=(48,30,00,N/125,15,00,W)
OCEAN=(48,00,00,N/125,07,30,W)
OCEAN=(48,07,30,N/125,07,30,W)
OCEAN=(48,15,00,N/125,07,30,W)
OCEAN=(48,22,30,N/125,07,30,W)
OCEAN=(48,30,00,N/125,07,30,W)
OCEAN=(49,00,00,N/128,00,00,W)
OCEAN=(49,07,30,N/128,00,00,W)
OCEAN=(49,15,00,N/128,00,00,W)
OCEAN=(49,22,30,N/128,00,00,W)
OCEAN=(49,30,00,N/128,00,00,W)
OCEAN=(49,37,30,N/128,00,00,W)
OCEAN=(49,45,00,N/128,00,00,W)
OCEAN=(49,52,30,N/128,00,00,W)
OCEAN=(49,00,00,N/127,52,30,W)
OCEAN=(49,07,30,N/127,52,30,W)
```

Figure 5-2. (Continued).

```
OCEAN=(49,15,00,N/127,52,30,W)
OCEAN=(49,22,30,N/127,52,30,W)
OCEAN=(49,30,00,N/127,52,30,W)
OCEAN=(49,37,30,N/127,52,30,W)
OCEAN=(49,45,00,N/127,52,30,W)
OCEAN=(49,52,30,N/127,52,30,W)
OCEAN=(49,00,00,N/127,45,00,W)
OCEAN=(49,07,30,N/127,45,00,W)
OCEAN=(49,15,00,N/127,45,00,W)
OCEAN=(49,22,30,N/127,45,00,W)
OCEAN=(49,30,00,N/127,45,00,W)
OCEAN=(49,37,30,N/127,45,00,W)
OCEAN=(49,45,00,N/127,45,00,W)
OCEAN=(49,52,30,N/127,45,00,W)
OCEAN=(49,00,00,N/127,37,30,W)
OCEAN=(49,07,30,N/127,37,30,W)
OCEAN=(49,15,00,N/127,37,30,W)
OCEAN=(49,22,30,N/127,37,30,W)
OCEAN=(49,30,00,N/127,37,30,W)
OCEAN=(49,37,30,N/127,37,30,W)
OCEAN=(49,45,00,N/127,37,30,W)
OCEAN=(49,00,00,N/127,30,00,W)
OCEAN=(49,07,30,N/127,30,00,W)
OCEAN=(49,15,00,N/127,30,00,W)
OCEAN=(49,22,30,N/127,30,00,W)
OCEAN=(49,30,00,N/127,30,00,W)
OCEAN=(49,37,30,N/127,30,00,W)
OCEAN=(49,45,00,N/127,30,00,W)
```

Figure 5-2. (Continued).

```
OCEAN=(49,00,00,N/127,22,30,W)
OCEAN=(49,07,30,N/127,22,30,W)
OCEAN=(49,15,00,N/127,22,30,W)
OCEAN=(49,22,30,N/127,22,30,W)
OCEAN=(49,30,00,N/127,22,30,W)
OCEAN=(49,37,30,N/127,22,30,W)
OCEAN=(49,45,00,N/127,22,30,W)
OCEAN=(49,00,00,N/127,15,00,W)
OCEAN=(49,07,30,N/127,15,00,W)
OCEAN=(49,15,00,N/127,15,00,W)
OCEAN=(49,22,30,N/127,15,00,W)
OCEAN=(49,30,00,N/127,15,00,W)
OCEAN=(49,37,30,N/127,15,00,W)
OCEAN=(49,00,00,N/127,07,30,W)
OCEAN=(49,07,30,N/127,07,30,W)
OCEAN=(49,15,00,N/127,07,30,W)
OCEAN=(49,22,30,N/127,07,30,W)
OCEAN=(49,30,00,N/127,07,30,W)
OCEAN=(49,37,30,N/127,07,30,W)
OCEAN=(49,00,00,N/127,00,00,W)
OCEAN=(49,07,30,N/127,00,00,W)
OCEAN=(49,15,00,N/127,00,00,W)
OCEAN=(49,22,30,N/127,00,00,W)
OCEAN=(49,30,00,N/127,00,00,W)
OCEAN=(49,00,00,N/126,52,30,W)
OCEAN=(49,07,30,N/126,52,30,W)
OCEAN=(49,15,00,N/126,52,30,W)
OCEAN=(49,22,30,N/126,52,30,W)
```

Figure 5-2. (Continued).

```
TOPOG TERRAIN DATA BASE GENERATION                                                80/05/20.  16.01.14.         PAGE    6
TOPOG FILE TG2628 - VICTORIA   (USA,CANADA)

                     OCEAN=(49,00,00,N/126,45,00,W)
                     OCEAN=(49,07,30,N/126,45,00,W)
                     OCEAN=(49,15,00,N/126,45,00,W)
                     OCEAN=(49,22,30,N/126,45,00,W)
                     OCEAN=(49,00,00,N/126,37,30,W)
                     OCEAN=(49,07,30,N/126,37,30,W)
                     OCEAN=(49,00,00,N/126,30,00,W)
                     OCEAN=(49,07,30,N/126,30,00,W)
                     OCEAN=(49,00,00,N/126,22,30,W)
                     OCEAN=(49,07,30,N/126,22,30,W)
                     OCEAN=(49,00,00,N/126,15,00,W)
                     OCEAN=(49,07,30,N/126,15,00,W)
                     OCEAN=(49,00,00,N/126,07,30,W)
                     OCEAN=(49,45,00,N/124,52,30,W)
                     OCEAN=(49,15,00,N/124,00,00,W)
                     OCEAN=(49,15,00,N/123,52,30,W)
                     OCEAN=(49,15,00,N/123,45,00,W)
                     OCEAN=(49,07,30,N/123,37,30,W)
                     OCEAN=(49,15,00,N/123,37,30,W)
                     OCEAN=(49,00,00,N/123,30,00,W)
                     OCEAN=(49,07,30,N/123,30,00,W)
                     OCEAN=(49,00,00,N/123,22,30,W)
      END OF INPUT DATA CARDS
     ** NOTE **  DATA FOR   141  OCEAN BLOCKS WAS WRITTEN ON TAPE 8 DURING DATA INPUT PHASE.
         IF OCEAN BLOCK DATA WAS INPUT WITH SYNTAX ERRORS, RELEVANT DIAGNOSTICS FOLLOW LISTING OF DATA.
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Figure 5-2. (Continued)

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TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)

TOPOG INPUT DATA SUMMARY
************************

TITLE:  TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)

INITIAL RUN

LATITUDE OF SW CORNER OF TOPOG TAPE AREA (TLATS):      45. DEGREES N

LONGITUDE OF SW CORNER OF TOPOG TAPE AREA (TLONW):    -129. DEGREES E

NUMBER OF REGIONS IN TOPOG TAPE AREA (NREG):   2

VSN OF TOPOG OUTPUT TAPE (TVSN):  TG2628    (NEW)

NAME OF TOPOG TAPE AREA:  VICTORIA

NUMBER OF SOURCE AREAS PER ROW (NSA):  ROW 1 =  2
                                       ROW 2 =  2
                                       ROW 3 =  2
                                       ROW 4 =  3
                                       ROW 5 =  2

SOURCE AREAS (SCRCE):              NUMBER OF SOURCE     CATEGORY CODE OR
                                        BLOCKS          VSN AND FILE NO.

                     AREA(1,1)            4                    0
                     AREA(1,2)            2                U8251  ( 1)
                     AREA(2,1)            4                    0
                     AREA(2,2)            2                U857   ( 1)
                     AREA(3,1)            4                    0
                     AREA(3,2)            2                U11856( 1)
                     AREA(4,1)            3                    0
                     AREA(4,2)            1                   -1
                     AREA(4,3)            2                U23129( 1)
                     AREA(5,1)            1                    0
                     AREA(5,2)            5                   -1

OCEAN BLOCKS (OCEAN):                 COORDINATES OF SOUTHWEST CORNER

                               DD/MM/SS                        DEC/DEGREES

                     ( 49,00,00,N/128,00,00,W)        ( 49.00,N/128.00,W)
                     ( 49,07,30,N/128,00,00,W)        ( 49.13,N/128.00,W)
                     ( 49,15,00,N/128,00,00,W)        ( 49.25,N/128.00,W)
                     ( 49,22,30,N/128.00,00,W)        ( 49.38,N/128.00,W)
                     ( 49,30,00,N/128,00,00,W)        ( 49.50,N/128.00,W)
                     ( 49,37,30,N/128,00.00,W)        ( 49.53,N/128.00,W)
                     ( 49,45,00,N/128,00,00,W)        ( 49.75,N/128.00,W)
                     ( 49,52,30,N/128,00,00,W)        ( 49.88,N/128.00,W)
                     ( 49,00,00,N/127,52,30,W)        ( 49.00,N/127.88,W)
                     ( 49,07,30,N/127,52,30,W)        ( 49.13,N/127.88,W)
                     ( 49,15,00,N/127,52,30,W)        ( 49.25,N/127.88,W)
                     ( 49,22,30,N/127,52,30,W)        ( 49.38,N/127.88,W)
                     ( 49,30,00,N/127,52,30,W)        ( 49.50,N/127.88,W)
                     ( 49,37,30,N/127,52,30,W)        ( 49.53,N/127.88,W)
                     ( 49,45,00,N/127,52,30,W)        ( 49.75,N/127.88,W)
                     ( 49,52,30,N/127,52,30,W)        ( 49.88,N/127.88,W)
```

Figure 5-2. (Continued).

(49,00,00,N/127,45,00,W)	(49.00,N/127.75,W)
(49,07,30,N/127,45,00,W)	(49.13,N/127.75,W)
(49,15,00,N/127,45,00,W)	(49.25,N/127.75,W)
(49,22,30,N/127,45,00,W)	(49.38,N/127.75,W)
(49,30,00,N/127,45,00,W)	(49.50,N/127.75,W)
(49,37,30,N/127,45,00,W)	(49.63,N/127.75,W)
(49,45,00,N/127,45,00,W)	(49.75,N/127.75,W)
(49,52,30,N/127,45,00,W)	(49.88,N/127.75,W)
(49,00,00,N/127,37,30,W)	(49.00,N/127.63,W)
(49,07,30,N/127,37,30,W)	(49.13,N/127.63,W)
(49,15,00,N/127,37,30,W)	(49.25,N/127.63,W)
(49,22,30,N/127,37,30,W)	(49.38,N/127.63,W)
(49,30,00,N/127,37,30,W)	(49.50,N/127.63,W)
(49,37,30,N/127,37,30,W)	(49.63,N/127.63,W)
(49,45,00,N/127,37,30,W)	(49.75,N/127.63,W)
(49,00,00,N/127,30,00,W)	(49.00,N/127.50,W)
(49,07,30,N/127,30,00,W)	(49.13,N/127.50,W)
(49,15,00,N/127,30,00,W)	(49.25,N/127.50,W)
(49,22,30,N/127,30,00,W)	(49.38,N/127.50,W)
(49,30,00,N/127,30,00,W)	(49.50,N/127.50,W)
(49,37,30,N/127,30,00,W)	(49.63,N/127.50,W)
(49,45,00,N/127,30,00,W)	(49.75,N/127.50,W)
(49,00,00,N/127,22,30,W)	(49.00,N/127.38,W)
(49,07,30,N/127,22,30,W)	(49.13,N/127.38,W)
(49,15,00,N/127,22,30,W)	(49.25,N/127.38,W)
(49,22,30,N/127,22,30,W)	(49.38,N/127.38,W)
(49,30,00,N/127,22,30,W)	(49.50,N/127.38,W)
(49,37,30,N/127,22,30,W)	(49.63,N/127.38,W)
(49,45,00,N/127,22,30,W)	(49.75,N/127.38,W)
(49,00,00,N/127,15,00,W)	(49.00,N/127.25,W)
(49,07,30,N/127,15,00,W)	(49.13,N/127.25,W)
(49,15,00,N/127,15,00,W)	(49.25,N/127.25,W)
(49,22,30,N/127,15,00,W)	(49.38,N/127.25,W)
(49,30,00,N/127,15,00,W)	(49.50,N/127.25,W)
(49,37,30,N/127,15,00,W)	(49.63,N/127.25,W)
(49,00,00,N/127,07,30,W)	(49.00,N/127.13,W)
(49,07,30,N/127,07,30,W)	(49.13,N/127.13,W)
(49,15,00,N/127,07,30,W)	(49.25,N/127.13,W)
(49,22,30,N/127,07,30,W)	(49.38,N/127.13,W)
(49,30,00,N/127,07,30,W)	(49.50,N/127.13,W)
(49,37,30,N/127,07,30,W)	(49.63,N/127.13,W)
(49,00,00,N/127,00,00,W)	(49.00,N/127.00,W)
(49,07,30,N/127,00,00,W)	(49.13,N/127.00,W)
(49,15,00,N/127,00,00,W)	(49.25,N/127.00,W)
(49,22,30,N/127,00,00,W)	(49.38,N/127.00,W)
(49,30,00,N/127,00,00,W)	(49.50,N/127.00,W)
(49,00,00,N/126,52,30,W)	(49.00,N/126.89,W)
(49,07,30,N/126,52,30,W)	(49.13,N/126.88,W)
(49,15,00,N/126,52,30,W)	(49.25,N/126.88,W)
(49,22,30,N/126,52,30,W)	(49.38,N/126.88,W)
(49,00,00,N/126,45,00,W)	(49.00,N/126.75,W)
(49,07,30,N/126,45,00,W)	(49.13,N/126.75,W)
(49,15,00,N/126,45,00,W)	(49.25,N/126.75,W)
(49,22,30,N/126,45,00,W)	(49.38,N/126.75,W)
(49,00,00,N/126,37,30,W)	(49.00,N/126.63,W)
(49,07,30,N/126,37,30,W)	(49.13,N/126.63,W)

Figure 5-2. (Continued).

(49,00,00,N/126,30,00,W)	(49.00,N/126.50,W)
(49,07,30,N/126,30,00,W)	(49.13,N/126.50,W)
(49,00,00,N/126,22,30,W)	(49.00,N/126.38,W)
(49,07,30,N/126,22,30,W)	(49.13,N/126.38,W)
(49,00,00,N/126,15,00,W)	(49.00,N/126.25,W)
(49,07,30,N/126,15,00,W)	(49.13,N/126.25,W)
(49,00,00,N/126,07,30,W)	(49.00,N/126.13,W)
(48,00,00,N/126,00,00,W)	(48.00,N/126.00,W)
(48,07,30,N/126,00,00,W)	(48.13,N/126.00,W)
(48,15,00,N/126,00,00,W)	(48.25,N/126.00,W)
(48,22,30,N/126,00,00,W)	(48.38,N/126.00,W)
(48,30,00,N/126,00,00,W)	(48.50,N/126.00,W)
(48,37,30,N/126,00,00,W)	(48.63,N/126.01,W)
(48,45,00,N/126,00,00,W)	(48.75,N/126.00,W)
(48,52,30,N/126,00,00,W)	(48.88,N/126.00,W)
(48,00,00,N/125,52,30,W)	(48.00,N/125.88,W)
(48,07,30,N/125,52,30,W)	(48.13,N/125.88,W)
(48,15,00,N/125,52,30,W)	(48.25,N/125.88,W)
(48,22,30,N/125,52,30,W)	(48.39,N/125.28,W)
(48,30,00,N/125,52,30,W)	(48.50,N/125.88,W)
(48,37,30,N/125,52,30,W)	(48.63,N/125.88,W)
(48,45,00,N/125,52,30,W)	(48.75,N/125.98,W)
(48,52,30,N/125,52,30,W)	(48.88,N/125.88,W)
(48,00,00,N/125,45,00,W)	(48.00,N/125.75,W)
(48,07,30,N/125,45,00,W)	(48.13,N/125.75,W)
(48,15,00,N/125,45,00,W)	(48.25,N/125.75,W)
(48,22,30,N/125,45,00,W)	(48.38,N/125.75,W)
(48,30,00,N/125,45,00,W)	(48.50,N/125.75,W)
(48,37,30,N/125,45,00,W)	(48.63,N/125.75,W)
(48,45,00,N/125,45,00,W)	(48.75,N/125.75,W)
(48,00,00,N/125,37,30,W)	(48.00,N/125.63,W)
(48,07,30,N/125,37,30,W)	(48.13,N/125.63,W)
(48,15,00,N/125,37,30,W)	(48.25,N/125.63,W)
(48,22,30,N/125,37,30,W)	(48.38,N/125.63,W)
(48,30,00,N/125,37,30,W)	(48.50,N/125.63,W)
(48,37,30,N/125,37,30,W)	(48.63,N/125.63,W)
(48,45,00,N/125,37,30,W)	(48.75,N/125.63,W)
(48,00,00,N/125,30,00,W)	(48.00,N/125.50,W)
(48,07,30,N/125,30,00,W)	(48.13,N/125.50,W)
(48,15,00,N/125,30,00,W)	(48.25,N/125.50,W)
(48,22,30,N/125,30,00,W)	(48.38,N/125.50,W)
(48,30,00,N/125,30,00,W)	(48.50,N/125.50,W)
(48,37,30,N/125,30,00,W)	(48.63,N/125.50,W)
(48,45,00,N/125,30,00,W)	(48.75,N/125.50,W)
(48,00,00,N/125,22,30,W)	(48.00,N/125.38,W)
(48,07,30,N/125,22,30,W)	(48.13,N/125.38,W)
(48,15,00,N/125,22,30,W)	(48.25,N/125.38,W)
(48,22,30,N/125,22,30,W)	(48.38,N/125.38,W)
(48,30,00,N/125,22,30,W)	(48.50,N/125.38,W)
(48,37,30,N/125,22,30,W)	(48.63,N/125.38,W)
(48,00,00,N/125,15,00,W)	(48.00,N/125.25,W)
(48,07,30,N/125,15,00,W)	(48.13,N/125.25,W)
(48,15,00,N/125,15,00,W)	(48.25,N/125.25,W)
(48,22,30,N/125,15,00,W)	(48.38,N/125.25,W)
(48,30,00,N/125,15,00,W)	(48.50,N/125.25,W)
(48,00,00,N/125,07,30,W)	(48.00,N/125.13,W)

Figure 5-2. (Continued).

(48,07,30,N/125,07,30,W)	(48.13,N/125.13,W)
(48,15,00,N/125,07,30,W)	(48.25,N/125.13,W)
(48,22,30,N/125,07,30,W)	(48.38,N/125.13,W)
(48,30,00,N/125,07,30,W)	(48.50,N/125.13,W)
(49,45,00,N/124,52,30,W)	(49.75,N/124.88,W)
(49,15,00,N/124,00,00,W)	(49.25,N/124.00,W)
(49,15,00,N/123,52,30,W)	(49.25,N/123.88,W)
(49,15,00,N/123,45,00,W)	(49.25,N/123.75,W)
(49,07,30,N/123,37,30,W)	(49.13,N/123.63,W)
(49,15,00,N/123,37,30,W)	(49.25,N/123.63,W)
(49,00,00,N/123,30,00,W)	(49.00,N/123.50,W)
(49,07,30,N/123,30,00,W)	(49.13,N/123.50,W)
(49,00,00,N/123,22,30,W)	(49.00,N/123.38,W)

Figure 5-2. (Continued).

TOPOG FILE TG2628 - VICTORIA (USA,CANADA)

```
TTTTTTTTT   OOOOOOOOO   PPPPPPPPP   OOOOOOOOO   GGGGGGGGG
    T       O       O   P       P   O       O   G
    T       O       O   P       P   O       O   G
    T       O       O   P       P   O       O   G
    T       O       O   PPPPPPPPP   O       O   G    GGGGG
    T       O       O   P           O       O   G        G
    T       O       O   P           O       O   G        G
    T       OOOOOOOOO   P           OOOOOOOOO   GGGGGGGGG
```

DIGITAL TERRAIN ELEVATION DATA

TAPE NUMBER (VSN)	TG2628
TAPE AREA NAME	VICTORIA
TAPE AREA BOUNDARIES	45 N - 50 N , 123 W - 123 W
DATE GENERATED	80/05/20.
ORGANIZATION ID	NTIA/ITS
LATITUDE GRID INTERVAL	3 SECONDS
LONGITUDE GRID INTERVAL	3 SECONDS

TOPOG REGIONS

2623	123 W - 125 W
2529	126 W - 123 W

Figure 5-2. (Continued).

BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

```
TAPE AREA  TG2628   VICTORIA                                   REGION 2628

               129 W     128 W     127 W     126 W
          50 N +         +         +         + 50 N
                 OOOOOOOO OOOMMMMM MMMMMMMM
                 OOOOOOOO OOOOOOMM MMMMMMMM
                 OOOOOOOO OOOOOOOO MMMMMMMM
                 OOOOOOOO OOOOOOOO OMMMMMMM
                 OOOOOOOO OOOOOOOO OOOMMMMM
                 OOOOOOOO OOOOOOOO OOOMMMMM
                 OOOOOOOO OOOOOOOO OOOOOOOM
                 OOOOOOOO OOOOOOOO OOOOOOOO
          49 N +         +         +         + 49 N
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
          48 N +         +         +         + 48 N
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
          47 N +         +         +         + 47 N
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
          46 N +         +         +         + 46 N
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
                 OOOOOOOO OOOOOOOO OOOOOOOO
          45 N +         +         +         + 45 N
               129 W     128 W     127 W     126 W

(DATA STATUS SYMBOLS    C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING)
```

Figure 5-2. (Continued).

```
TOPOG TERRAIN DATA BASE GENERATION                                          80/05/20.   16.01.14.        PAGE  13
TOPOG FILE TG2628 - VICTORIA  (USA,CANADA)

                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

              TAPE AREA  TG2628   VICTORIA                                     REGION 2629

                             126 W     125 W     124 W     123 W
                        50 N +         +         +         + 50 N
                               MMMMMMMM MMMMMMMM MMMMMMMM
                               MMMMMMMM MOMMMMMM MMMMMMMM
                               MMMMMMMM MMMMMMMM MMMMMMMM
                               MMMMMMMM MMMMMMMM MMMMMMMM
                               MMMMMMMM MMMMMMMM MMMMMMMM
                               MMMMMMMM MMMMMMMM OOOOMMMM
                               MMMMMMMM MMMMMMMM MMMCOMMM
                               MMMMMMMM MMMMMMMM MMMMOOMM
                        49 N +         +         +         + 49 N
                               OOMMMMMM CCCCCCCC CCCCCCCC
                               OOOOCMMM CCCCCCCC CCCCCCCC
                               OOOOOOMM CCCCCCCC CCCCCCCC
                               OOOOOOOO OCCCCCCC CCCCCCCC
                               OOOOOOOO OOCCOCCC CCCCCCCC
                               OOOOOOOO OOCCCCCO CCCCOOOO
                               OOOOOOOO OCCCCCCC CCCCCCCC
                               OOOOOOOO OOCCCCCC CCCCCCCC
                        48 N +         +         +         + 48 N
                               OOOOOOOO OOCCCCCC CCCCCCCC
                               OOOOOOOO OOOCCCCC CCCCCCCC
                               OOOOOOOO OOOOCCCC CCCCCCCC
                               OOOOOOOO OOOOCCCC CCCCCCCC
                               OOOOOOOO OOOOOCCC CCCCCCCC
                               OOOOOOOO OOOOOCCC CCCCCCCC
                               OOOOOOOO COOOOOCC CCCCCCCC
                               OOOOOOOO OCOOOOCC CCCCCCCC
                        47 N +         +         +         + 47 N
                               OOOOOOOO OOOCOOCC CCCCCCCC
                               OOOOOOOO OOOOOOOC CCCCCCCC
                               OOOOOOOO COOOOOOC CCCCCCCC
                               OOOOOOOO OOCOOOOC CCCCCCCC
                               OOOOOOOO OCCOOOCC CCCCCCCC
                               COOOOOOO OOOCOOOC CCCCCCCC
                               OCOOOOOO OCOOOOOC CCCCCCCC
                               OOOOOOOO OOOCOOOO CCCCCCCC
                        46 N +         +         +         + 46 N
                               OOOOOOOO OOOOCOOO CCCCCCCC
                               OOOOOOOO OOOCOOOO CCCCCCCC
                               COOOCOCO OOCCOOOO CCCCCCCC
                               COOOOOOO OOCCOOOO CCCCCCCC
                               OOOOOOOO OOCOOCOO CCCCCCCC
                               OOOOOOOO OOOCOOOC CCCCCCCC
                               OOOOOOOO OOOCOOOO CCCCCCCC
                               COOOOCOO OOOOCOOO CCCCCCCC
                        45 N +         +         +         + 45 N
                             126 W     125 W     124 W     123 W

             (DATA STATUS SYMBOLS      C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING)
```

Figure 5-2. (Continued).

```
16.01.02.TOPO,T1777.
16.01.02.USER(EMCAD)
16.01.02.CHARGE,910,910XXXX.
16.01.03.ATTACH,GENTOP.
16.01.09.RESOURC,NT=2.
16.01.13.GENTOP(PL=10000)
16.01.13.*GENTOP MODEL*
16.12.44.NT63, ASSIGNED TO TOPDRY , VSN=TG0000.
16.16.56.NT65, ASSIGNED TO SOURCE , VSN=U8251 .
18.09.41.UCMS,   1048.576KUNS.
18.35.56.NT62, ASSIGNED TO SOURCE , VSN=U857   .
19.39.21.UCMS,   1048.576KUNS.
21.02.06.NT62, ASSIGNED TO SOURCE , VSN=U11856.
21.41.06.UCMS,   1048.576KUNS.
22.17.58.NT62, ASSIGNED TO SOURCE , VSN=U23129.
23.02.47.UCMS,   1048.576KUNS.
01.28.24.NT62, ASSIGNED TO TOPOG  , VSN=TG2628.
01.30.07.   ALL SOURCE BLOCKS PROCESSED
01.30.07.   EXECUTION TIME IN CP SECONDS =
01.30.07.  7.41811999999995  E+002
01.30.07.*GENTOP RUN COMPLETE*
01.30.07.    STOP
01.30.07.    140400 MAXIMUM EXECUTION FL.
01.30.07.   741.827 CP SECONDS EXECUTION TIME.
01.30.08.DAYFILE(TG2628D)
01.30.08. USER DAYFILE DUMPED.
01.28.08.REPLACE(TG2628D)
01.30.09.EXIT.
01.30.09.UEAD,      0.087KUNS.
01.30.09.UEPF,      0.540KUNS.
01.30.09.UEMT,     46.869KUNS.
01.30.09.UEMS,    572.054KUNS.
01.30.09.UECP,    754.050SECS.
01.30.09.AESR,   2937.217UNTS.
11.08.52.UCLP, BB41,     0.960KLNS.
```


Figure 5-2. (Continued).

```
TOPOG TERRAIN DATA BASE GENERATION                                    80/05/24.   06.57.30.      PAGE    1
TOPOG FILE  TG2630 - SEATTLE  (USA,CANADA)

              TOPOG FILE  TG2630 - SEATTLE  (USA,CANADA)

              TLATS=(45,N)

              TLONW=(123,W)

              NREG=1

              TVSN=(TG2630,NEW,SEATTLE)

              NSA(1)=1

              NSA(2)=1

              NSA(3)=1

              NSA(4)=1

              NSA(5)=1

              SORCE(1,1)=(3,U8251,3)

              SORCE(2,1)=(3,U857,3)

              SORCE(3,1)=(3,U11856,3)

              SORCE(4,1)=(3,U23129,3)

              SORCE(5,1)=(3,-1)

   END OF INPUT DATA CARDS

** NOTE **  DATA FOR     0  OCEAN BLOCKS WAS WRITTEN ON TAPE 8 DURING DATA INPUT PHASE.
    IF OCEAN BLOCK DATA WAS INPUT WITH SYNTAX ERRORS, RELEVANT DIAGNOSTICS FOLLOW LISTING OF DATA.
```

Figure 5-3. GENTOP output for generation of TOPOG file TG2630 - Seattle (USA,CANADA).

```
TOPOG TERRAIN DATA BASE GENERATION                                                        80/05/24.   06.57.30.          PAGE    2
TOPOG FILE  TG2630 - SEATTLE  (USA,CANADA)

TOPOG INPUT DATA SUMMARY
************************

TITLE:  TOPOG FILE  TG2630 - SEATTLE  (USA,CANADA)

INITIAL RUN

LATITUDE OF SW CORNER OF TOPOG TAPE AREA (TLATS):     45. DEGREES N

LONGITUDE OF SW CORNER OF TOPOG TAPE AREA (TLONW):   -123. DEGREES E

NUMBER OF REGIONS IN TOPOG TAPE AREA (NREG):   1

VSN OF TOPOG OUTPUT TAPE (TVSN):  TG2630   (NEW)

NAME OF TOPOG TAPE AREA:  SEATTLE

NUMBER OF SOURCE AREAS PER ROW (NSA):  ROW 1 =  1
                                       ROW 2 =  1
                                       ROW 3 =  1
                                       ROW 4 =  1
                                       ROW 5 =  1

SOURCE AREAS (SORCE):            NUMBER OF SOURCE    CATEGORY CODE OR
                                      BLOCKS         VSN AND FILE NO.

                     AREA(1,1)          3              U8251  ( 3)
                     AREA(2,1)          3              U857   ( 3)
                     AREA(3,1)          3              U11356( 3)
                     AREA(4,1)          3              U23129( 3)
                     AREA(5,1)          3                 -1
```

Figure 5-3. (Continued).

```
TTTTTTTTT   000000000   PPPPPPPPP   000000000   GGGGGGGGG
    T       0       0   P       P   0       0   G
    T       0       0   P       P   0       0   G
    T       0       0   P       P   0       0   G
    T       0       0   PPPPPPPPP   0       0   G    GGGGG
    T       0       0   P           0       0   G        G
    T       0       0   P           0       0   G        G
    T       000000000   P           000000000   GGGGGGGGG
```

DIGITAL TERRAIN ELEVATION DATA

TAPE NUMBER (VSN)	TG2630
TAPE AREA NAME	SEATTLE
TAPE AREA BOUNDARIES	45 N - 50 N , 123 W - 120 W
DATE GENERATED	80/05/24.
ORGANIZATION ID	NTIA/ITS
LATITUDE GRID INTERVAL	3 SECONDS
LONGITUDE GRID INTERVAL	3 SECONDS

TOPOG REGIONS

2630 123 W - 120 W

Figure 5-3. (Continued).

```
                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

            TAPE AREA  TG2630   SEATTLE                                              REGION 2630

                                 123 W     122 W     121 W     120 W
                             50 N +         +         +         + 50 N
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                                   MMMMMMMM MMMMMMMM MMMMMMMM
                             49 N +         +         +         + 49 N
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                             48 N +         +         +         + 48 N
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                             47 N +         +         +         + 47 N
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                             46 N +         +         +         + 46 N
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                                   CCCCCCCC CCCCCCCC CCCCCCCC
                             45 N +         +         +         + 45 N
                                 123 W     122 W     121 W     120 W

            (DATA STATUS SYMBOLS     C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING)
```

Figure 5-3. (Continued).

```
ADLYAAH. 80/05/24.N.O.A.A./E.R.L.. 6600B  80/05/16.

06.55.40.TOPO,T1777.
06.55.42.USER(EMCAD)
06.55.42.CHARGE,910,910XXXX.
06.55.46.ATTACH,GENTOP.
06.56.30.RESOURC,NT=2.
06.57.29.GENTOP(PL=10000)
06.57.29.*GENTOP MODEL*
06.59.50.NT65, ASSIGNED TO TOPORY , VSN=TG0000.
07.17.18.NT60, ASSIGNED TO SOURCE , VSN=U8251 .
08.03.15.UCMS,   1048.576KUNS.
09.32.34.NT60, ASSIGNED TO SOURCE , VSN=U857  .
09.43.01.UCMS,   1048.576KUNS.
010.28.56.UCMS,   1048.576KUNS.
11.43.28.NT60, ASSIGNED TO SOURCE , VSN=U11856.
12.04.12.UCMS,   1048.576KUNS.
12.50.08.UCMS,   1048.576KUNS.
13.29.26.NT60, ASSIGNED TO SOURCE , VSN=U23129.
14.06.25.UCMS,   1048.576KUNS.
14.52.16.UCMS,   1048.576KUNS.
15.18.38.NT61, ASSIGNED TO TOPOG  , VSN=TG2630.
15.21.43.   ALL SOURCE BLOCKS PROCESSED
15.21.43.   EXECUTION TIME IN CP SECONDS =
15.21.43.  1.50575399999999  E+003
15.21.43.*GENTOP RUN COMPLETE*
15.21.43.    STOP
15.21.43.    140608 MAXIMUM EXECUTION FL.
15.21.43.  1505.763 CP SECONDS EXECUTION TIME.
15.21.43.DAYFILE(TG2630D)

15.21.43.DAYFILE(TG2630D)
15.21.44. USER DAYFILE DUMPED.
15.21.44.REPLACE(TG2630D)
15.21.44.EXIT.
15.21.44.UEAD,       0.007KUNS.
15.21.44.UEPF,       1.498KUNS.
15.21.44.UEMT,      96.005KUNS.
15.21.44.UEPS,     355.708KUNS.
15.21.44.UECP,    1263.580SECS.
15.21.44.AESR,    4646.200UNTS.
15.22.12.UCLP, 8841,       0.576KLNS.
```

Figure 5-3. (Continued).

```
TOPOG TERRAIN DATA BASE GENERATION                                      80/06/06.   09.16.27.        PAGE    1
TOPOG FILE  TG2631 - SPOKANE   (USA,CANADA)

          TOPOG FILE   TG2631 - SPOKANE   (USA,CANADA)
          TLATS=(45,N)
          TLONW=(120,W)
          NREG=1
          TVSN=(TG2631,REPLACE,SPOKANE)
          NSA(1)=1
          NSA(2)=1
          NSA(3)=1
          NSA(4)=1
          NSA(5)=1
          SCRCE(1,1)=(3,U8251,6)
          SCRCE(2,1)=(3,U857,6)
          SCRCE(3,1)=(3,U11856,6)
          SCRCE(4,1)=(3,U23129,6)
          SCRCE(5,1)=(3,-1)
   END OF INPUT DATA CARDS

 ** NOTE **  DATA FOR     0  OCEAN BLOCKS WAS WRITTEN ON TAPE 8 DURING DATA INPUT PHASE.
    IF OCEAN BLOCK DATA WAS INPUT WITH SYNTAX ERRORS, RELEVANT DIAGNOSTICS FOLLOW LISTING OF DATA.
```

Figure 5-4. GENTOP output for generation of TOPOG file TG2631 - Spokane (USA,CANADA).

TOPOG INPUT DATA SUMMARY
****

TITLE: TOPOG FILE TG2531 - SPOKANE (USA,CANADA)

INITIAL RUN

LATITUDE OF SW CORNER OF TOPOG TAPE AREA (TLATS): 45. DEGREES N

LONGITUDE OF SW CORNER OF TOPOG TAPE AREA (TLONW): -120. DEGREES E

NUMBER OF REGIONS IN TOPOG TAPE AREA (NREG): 1

VSN OF TOPOG OUTPUT TAPE (TVSN): TG2531 (REPLACE)

NAME OF TOPOG TAPE AREA: SPOKANE

NUMBER OF SOURCE AREAS PER ROW (NSA): ROW 1 = 1
ROW 2 = 1
ROW 3 = 1
ROW 4 = 1
ROW 5 = 1

SOURCE AREAS (SORCE):	NUMBER OF SOURCE BLOCKS	CATEGORY CODE OR VSN AND FILE NO.
AREA(1,1)	3	U8251 (6)
AREA(2,1)	3	U857 (6)
AREA(3,1)	3	U11856(6)
AREA(4,1)	3	U23129(6)
AREA(5,1)	3	-1

Figure 5-4. (Continued).

```
TTTTTTTTT  000000000  PPPPPPPPP  000000000  GGGGGGGGG
    T      0       0  P       P  0       0  G
    T      0       0  P       P  0       0  G
    T      0       0  P       P  0       0  G
    T      0       0  PPPPPPPPP  0       0  G    GGGGG
    T      0       0  P          0       0  G        G
    T      0       0  P          0       0  G        G
    T      000000000  P          000000000  GGGGGGGGG
```

DIGITAL TERRAIN ELEVATION DATA

TAPE NUMBER (VSN)	TG2631
TAPE AREA NAME	SPOKANE
TAPE AREA BOUNDARIES	45 N - 50 N , 120 W - 117 W
DATE GENERATED	80/06/06.
ORGANIZATION ID	NTIA/ITS
LATITUDE GRID INTERVAL	3 SECONDS
LONGITUDE GRID INTERVAL	3 SECONDS

TOPOG REGIONS

2631 120 W - 117 W

Figure 5-4. (Continued).

```
TOPOG TERRAIN DATA BASE GENERATION                                                    80/06/06.   09.18.27.        PAGE     4
TOPOG FILE  TG2631 - SPOKANE  (USA,CANADA)

                                 BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

                      TAPE AREA  TG2631   SPOKANE                                           REGION 2631

                                         120 W     119 W     118 W     117 W
                                    50 N +         +         +         + 50 N
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                            MMMMMMMM MMMMMMMM MMMMMMMM
                                    49 N +         +         +         + 49 N
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                    48 N +         +         +         + 48 N
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                    47 N +         +         +         + 47 N
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                    46 N +         +         +         + 46 N
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                            CCCCCCCC CCCCCCCC CCCCCCCC
                                    45 N +         +         +         + 45 N
                                         120 W     119 W     118 W     117 W

                      (DATA STATUS SYMBOLS      C = COMPLETE   P = PARTIAL  O = OCEAN   M = MISSING)
```

Figure 5-4. (Continued).

```
ADLYAKZ. 80/06/07.N O A A / E R L  66008  80/05/16.

09.18.21.TOPO,T177.
09.18.21.USER(EMCAD)
09.18.21.CHARGE,910,910XXXX.
09.18.22.ATTACH,GENTOP.
09.18.24.RESOURC,NT=2.
09.18.25.GENTOP(PL=10000)
09.18.26.*GENTOP MODEL*
10.22.14.NT65, ASSIGNED TO TOPDRY, VSN=TG0000.
10.33.52.NT61, ASSIGNED TO SOURCE , VSN=U8251 .
21.54.08.UCMS,    1048.576KUNS.
23.33.08.NT60, ASSIGNED TO SOURCE , VSN=U857  .
23.49.33.UCMS,    1048.576KUNS.
00.51.00.UCMS,    1048.576KUNS.
01.24.39.NT61, ASSIGNED TO SOURCE , VSN=U11856.
01.58.32.UCMS,    1048.576KUNS.
03.04.17.NT60, ASSIGNED TO SOURCE , VSN=U23129.
04.52.15.NT62, ASSIGNED TO SOURCE , VSN=TG2631.
04.55.09.   ALL SOURCE BLOCKS PROCESSED
```

Figure 5-4. (Continued).

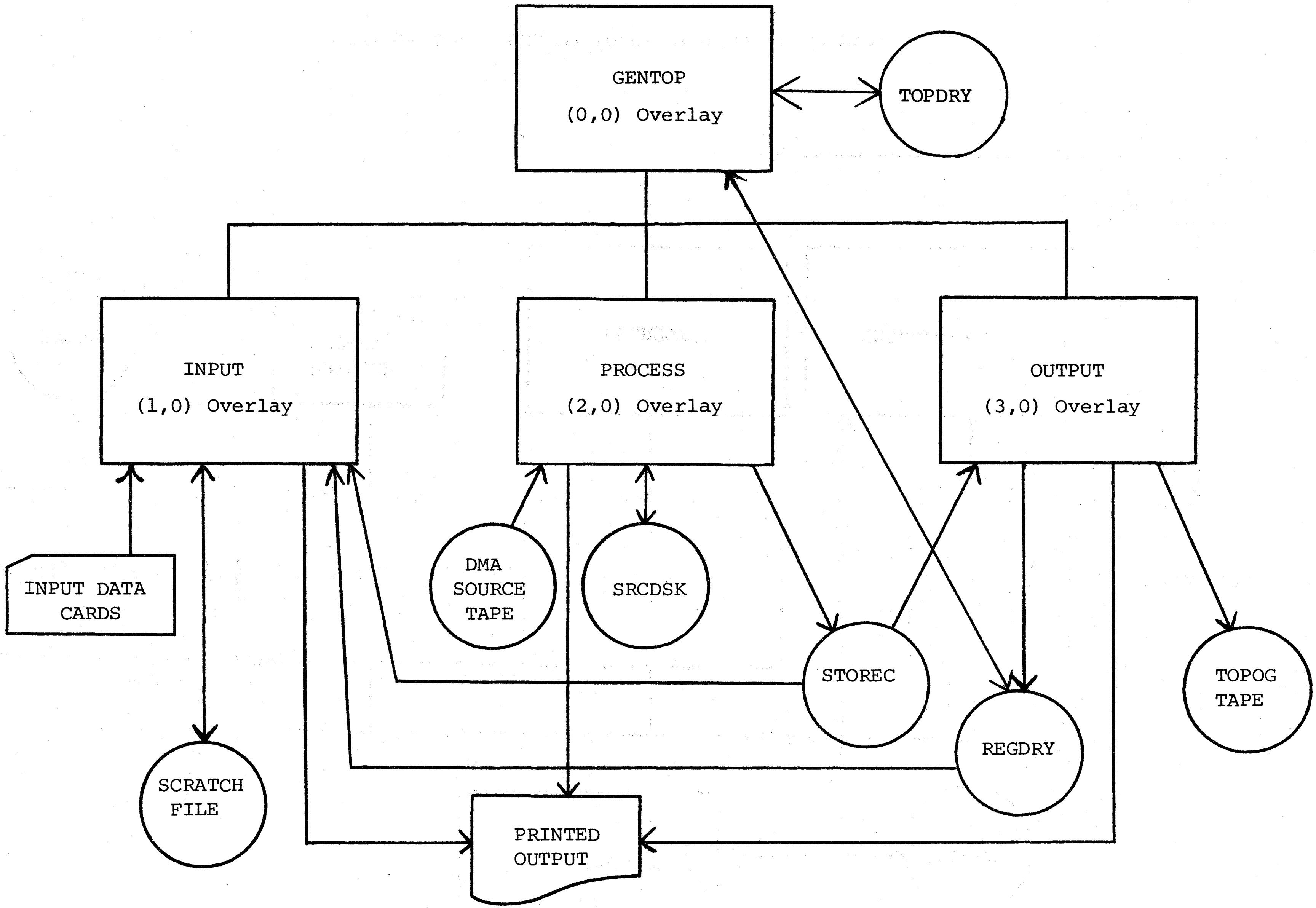


Figure 5-5. GENTOP structure.

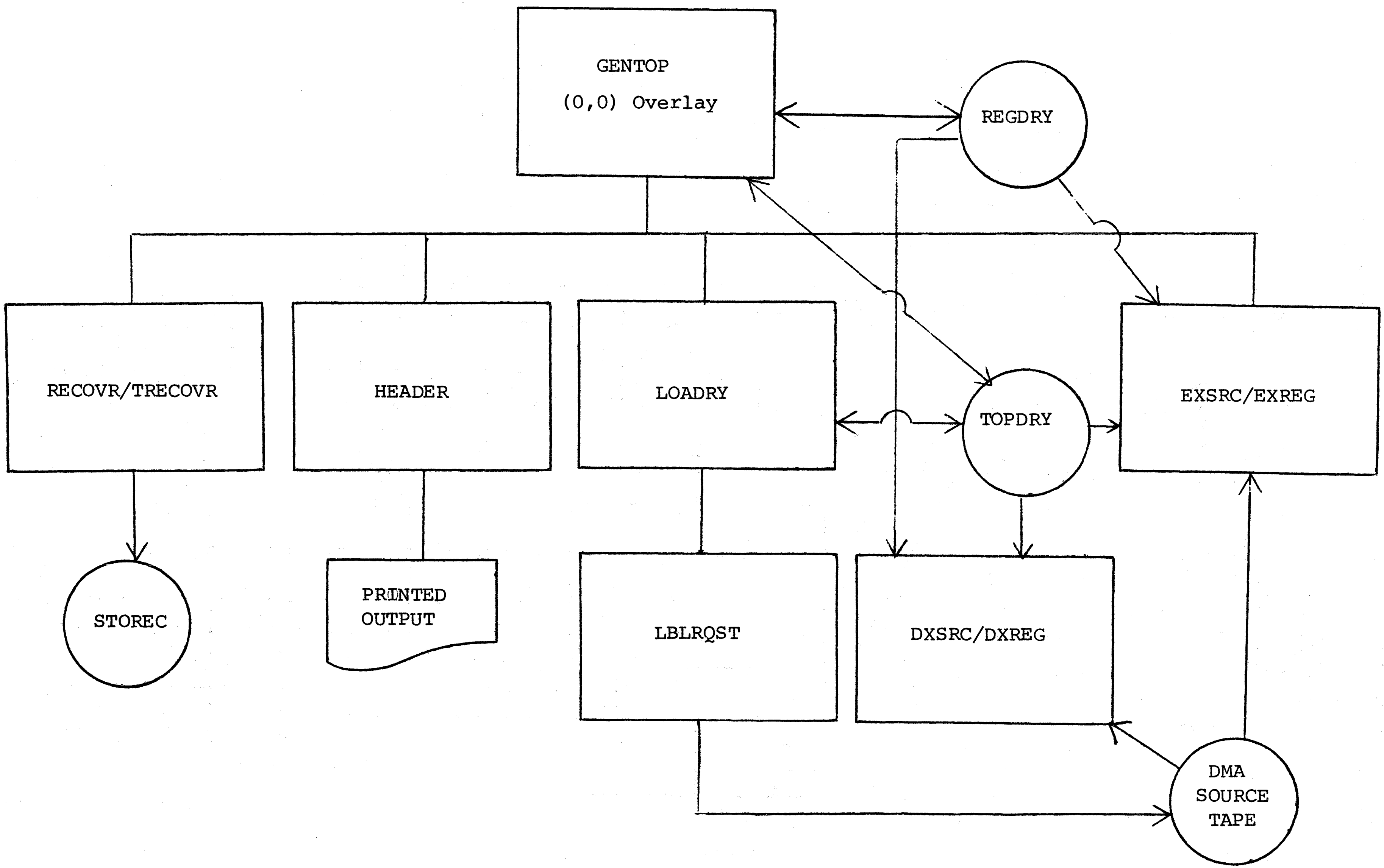


Figure 5-6. GENTOP (0,0) overlay structure.

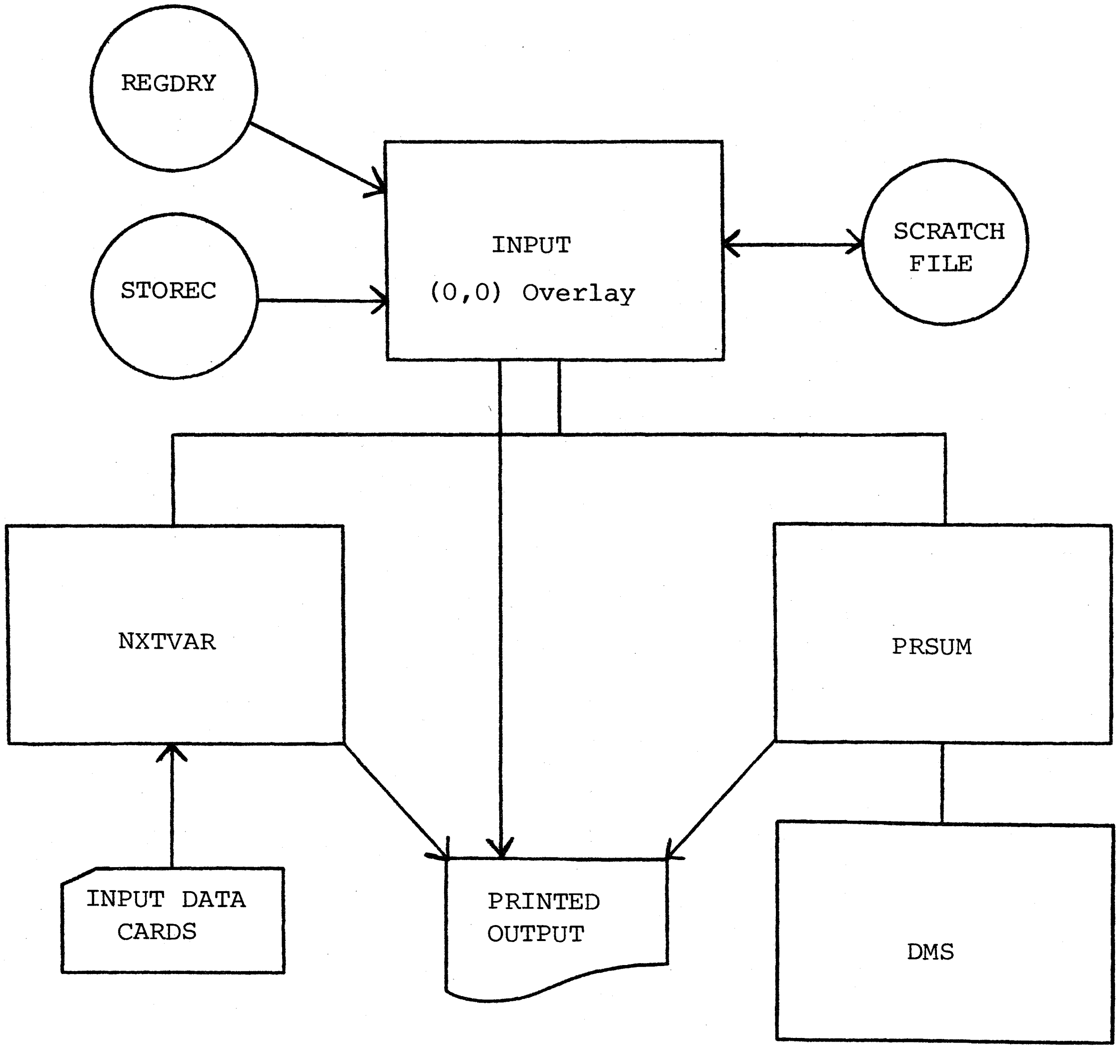


Figure 5-7. INPUT (1,0) overlay structure.

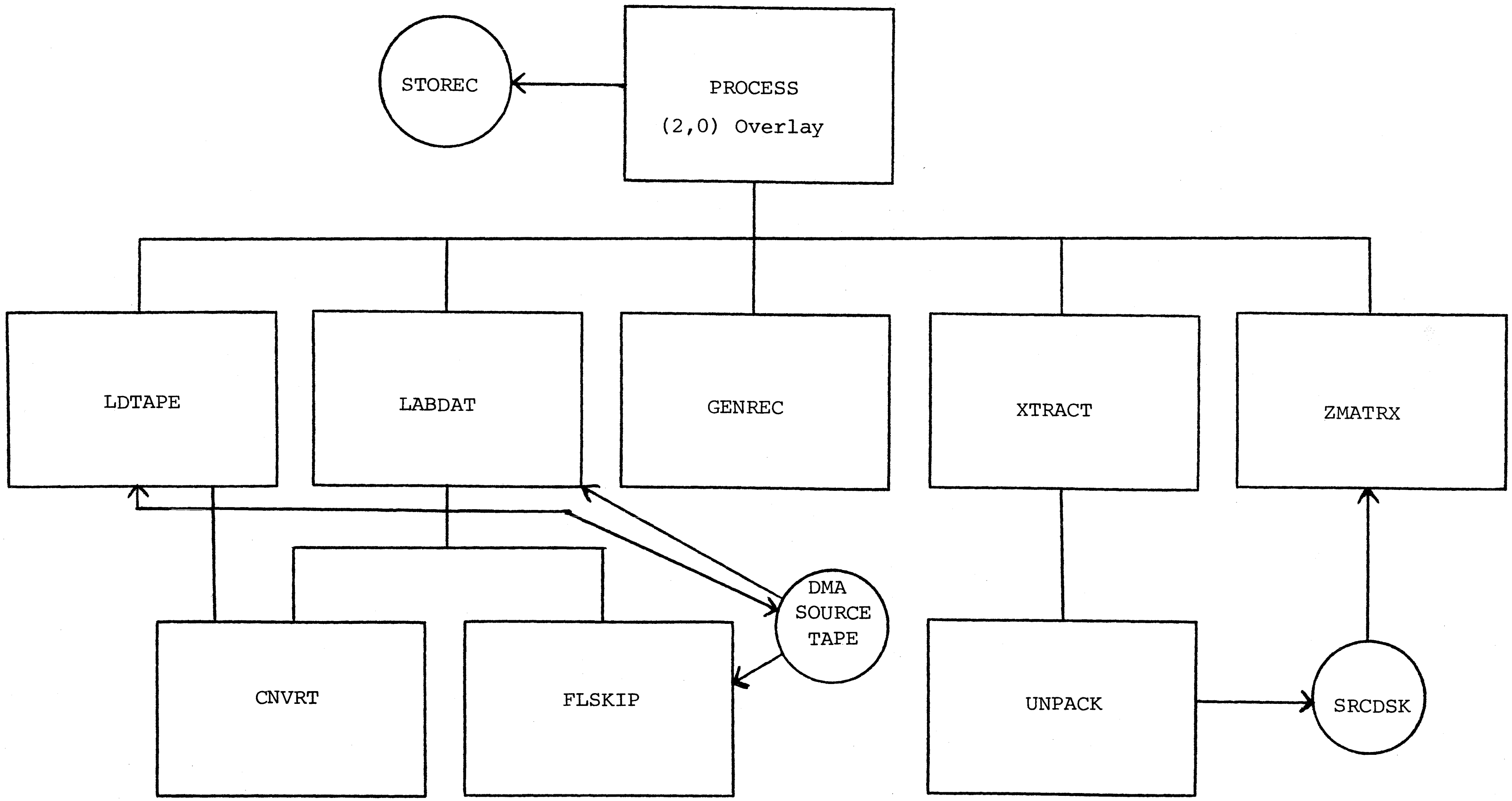


Figure 5-8. PROCESS (2,0) overlay structure.

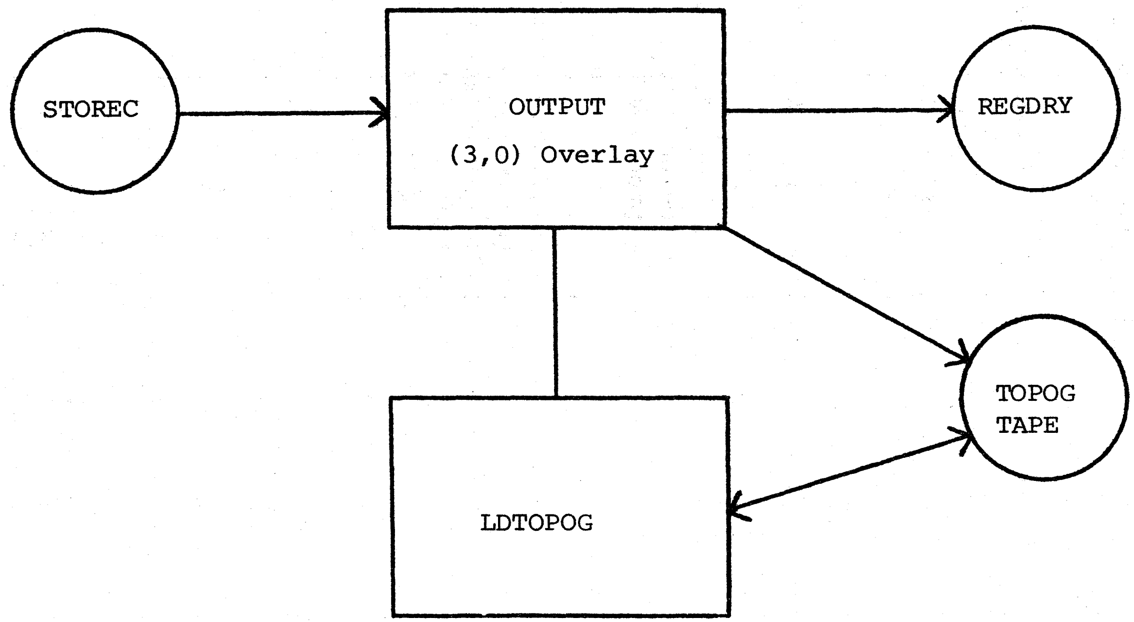


Figure 5-9. OUTPUT (3,0) overlay structure.

Table 5-4. GENTOP Files

File Name	Description
TOPDRY	TOPOG directory file (see Section 2.3.5)
REGDRY	TOPOG directory file (disk version)
TOPOG	TOPOG terrain elevation file (see Section 2.3.1)
SOURCE	UNIVAC DMA source tape (see Section 5.2.2)
SRCDSK	Word addressable scratch file used to contain DMA source data for one column of blocks to be processed
STOREC	Random-access MSIO indexed file used to contain completed TOPOG source blocks before they are written to the TOPOG tape. It is also used for storing program status information for restart runs.

Table 5-5. GENTOP Common Blocks

Common Block /GLOBAL/

ITITLE	Title of current run
IDATE	Current date
ITIME	Current time
NERR	Number of fatal errors
IRESTRT	Restart flag
IRTITLE	Title read from restart run
IRDATE	Date read from restart file
IRTIME	Time read from restart file
KODREG	Region directory array of biased region category codes
TLATS	Latitude of SW corner of TOPOG tape area
TLONW	Longitude of SW corner of TOPOG tape area
NREG	Number of regions in TOPOG tape area
ITVSN	VSN of TOPOG tape to be written
NSA	Array of number of source areas in each row
IREG	Global index of initial region in TOPOG tape area
IOCEAN	Ocean block flag array (1=ocean)
NEWFLG	=0 if tape declared new, =1 if declared replace
SALONE	Array of east boundary longitudes for each source area
KODSOR	Array of source area category codes
KINDEX	MSIO index for file STOREC
IPRONAM	ID of agency or organization generating TOPOG tape

Table 5-5. (Continued)

KEYS	Key for last TOPOG block data record written to STOREC by district
NDC	Number of district columns in TOPOG tape area
RLODIM	Longitude dimension of TOPOG region (degrees)
DLODIM	Longitude dimension of TOPOG district (degrees)
BLODIM	Longitude dimension of TOPOG block (degrees)
LGLOBAL	Length of common block /GLOBAL/
IDSREC	Source ID for TOPOG block data record
NOBLOK	Cumulative non-ocean block count (by district)
NAMTAP	Name of TOPOG tape area

Common block /ZFIT/

IFIT	FIT/FET for file SRCDSK
IBUFF	Record Manager buffer for file SRCDSK
JFIT	FIT/FET for file SOURCE
JBUFF	Record Manager buffer for file SOURCE
JSFILE	Current file position of file SOURCE (-1=beginning of volume, else file no.)
KFIT	FIT/FET for file REGDRY
KBUFF	Record Manager buffer for file REGDRY
MFIT	FIT/FET for file TOPDRY
MBUFF	Record Manager buffer for file TOPDRY
NFIT	FIT/FET for file TOPOG
NBUFF	Record Manager buffer for file TOPOG

Table 5-5. (Continued)

Common block /FLAGS/

JSTATUS	Status flag for file SOURCE (0=ok, -1=end of data, 1=error)
MSTATUS	Status flag for files TOPDRY/REGDRY (0=ok, -1=end of data, 1=error)

Common block /LOCDAT/

ISFILE	Sequence number of the file on the DMA source tape containing data for the current TOPOG block column
LODVSN	Volume serial number of the DMA source tape currently mounted
DLATS	Latitude of the southwest corner of the DMA source block containing the current TOPOG block column (decimal degrees N)
LONGIN	Longitude grid interval for source data (seconds)

Common block /ZDATA/

IZMAT	151 x 151 matrix of DMA source terrain elevation values at grid points of TOPOG blocks
IBKDAT	TOPOG block data record

Table 5-6. GENTOP Variable Directory

Name	Description
ISR	Source area row index
ISC	Intrarow index of source area
IDR	TOPOG district row index
IDC	TOPOG district column index
IDIS	TOPOG district index
IBR	TOPOG block row index
IBC	TOPOG block column index
IBLK	TOPOG block index
IRR	Zone index of TOPOG region
IRC	Intrazone index of TOPOG region
IREG	GLOBAL index of TOPOG region
TLATS	South boundary latitude of TOPOG tape area
TLATN	North boundary latitude of TOPOG tape area
TLONW	West boundary longitude of TOPOG tape area
TLONE	East boundary longitude of TOPOG tape area
TLODIM	Longitude dimension of TOPOG tape area
DLATS	South boundary latitude of TOPOG district
DLATN	North boundary latitude of TOPOG district
DLONW	West boundary longitude of TOPOG district
DLONE	East boundary longitude of TOPOG district
BLATS	South boundary latitude of TOPOG block

Table 5-6. (Continued)

Name	Description
BLATN	North boundary latitude of TOPOG block
BLONW	West boundary longitude of TOPOG block
BLONE	East boundary longitude of TOPOG block
RLATS	South boundary latitude of TOPOG region
RLATN	North boundary latitude of TOPOG region
RLONW	West boundary longitude of TOPOG region
RLONE	East boundary longitude of TOPOG region

the execution flow of the program by loading sub-overlays as they are needed. GENTOP issues dayfile messages to inform the user of any errors that have occurred, the number of source blocks processed during the run, and the execution time in CP seconds. It also opens and closes the files TOPDRY and REGDRY which contain the TOPOG region directory, the random-access MSIO file STOREC used to store intermediate data blocks that are later written to the TOPOG tape, and the global values necessary for a restart run. The subroutines RECOVR and TRECOVR handle the error processing necessary for the restart capability of GENTOP. HEADER controls the pagination of the output listing. LOADRY requests the tape containing the TOPOG directory file TOPDRY. LBLRQST issues tape requests for the DMA source tapes and the generated TOPOG tapes. DXSRC/DXREG and EXSRC/EXREG are the end-of-data and error-exit routines used to handle Record Manager errors on the files SOURCE and TOPDRY/REGDRY.

The (1,0) overlay includes the program INPUT and subroutines NXTVAR, DMS, and PRSUM. INPUT reads and processes the free-format input data cards used to select program options and provide information about the TOPOG tape area and DMA source areas. Each card is printed when it is read, so that diagnostics will follow the card containing the error. If a syntax error is encountered, the rest of the card will be skipped. Each input value must be given on a separate card. The keywords and their associated option or data values are checked for validity and the proper information is stored in common block /GLOBAL/. Some initialization values are also set that depend on the particular topographic region to be processed. Subroutine NXTVAR is used to crack the free-format card into fields, and DMS to convert latitude/longitude pairs into a print-ready Hollerith format in positive degrees/minutes/seconds and decimal degrees together with the proper direction. Subroutine PRSUM prints a summary of the input data values to be used in the GENTOP run.

The (2,0) overlay includes the program PROCESS and subroutines LDTAPE, LABDAT, CNVRT, XTRACT, ZMATRX, GENREC, UNPACK, and FLSKIP. PROCESS is the controlling routine of the (2,0) overlay. It extracts the terrain elevation data from the desired DMA standard tapes, generates the TOPOG block data and directory records, and saves them on file STOREC for use in creating the final TOPOG tape. Subroutine LDTAPE calls LBLRQST to request the desired DMA standard tape. LABDAT then reads and checks the pseudo-ANSI standard labels and positions the DMA tape to the data file for the desired area. CNVRT converts the ASCII labels to CDC display code. PROCESS uses subroutine UNPACK to unpack the 16-bit integer values from the DMA integer format into CDC 6600 integer format. The unpacked data are then written to the Record Manager word-addressable file SRCDSK for a 1/8° x 1° area at a time. Subroutine ZMATRX randomly reads data from SRCDSK to create a 151 x 151 array of terrain elevation values corresponding to the grid points of the next TOPOG block to be processed. GENREC creates the block data record for the output TOPOG tape from this array of terrain elevation values. FLSKIP is used to skip files on the DMA standard tape.

The (3,0) overlay includes the program OUTPUT and subroutine LDTOPOG. OUTPUT revises the directory records and writes them together with preface information and the block data records from STOREC to the finished TOPOG tape. LDTOPOG calls LBLRQST to request the proper TOPOG output tape to be written. OUTPUT also prints a summary map showing the status of each block in the tape area generated--complete, partial, ocean, or missing.

5.3.1 GENTOP

GENTOP is the main program of the (0,0) overlay. It issues the initial message "GENTOP MODEL" to the dayfile and calls the system clock to obtain the starting time in seconds. It then initializes the system recovery capability by calling the FORTRAN library routine RECOVR. Recovery is selected for all abnormal termination conditions and the routine TRECOVR is specified to be executed if a recovery occurs. GENTOP next creates the file information table (FIT) for the TOPOG directory file TOPDRY (tape), requests the tape, and opens the file. It then creates the FIT for the TOPOG directory file REGDRY (disk), opens the file, and copies the contents of TOPDRY to REGDRY. GENTOP next opens the random-access MSIO file STOREC with index array KINDEX. GENTOP then loads the (1,0) overlay and transfers control to INPUT. When all the input data cards have been read and processed, the (1,0) overlay will return control to GENTOP. If errors were found during the input processing, GENTOP displays the number of errors encountered in the dayfile and terminates the run. Otherwise, GENTOP checks the flag IRESTRT to see if this is a restart run that should begin with the (3,0) output overlay. If so, it will skip the (2,0) process overlay and call the (3,0) overlay next. If this is an initial run, or a restart run that had not completed generating all the TOPOG data blocks, the (2,0) process overlay will be loaded next. If no errors are detected in processing the TOPOG data blocks, GENTOP then loads the (3,0) overlay and transfers control to OUTPUT. If no errors are detected OUTPUT copies REGDRY back to TOPDRY. When the run is complete, GENTOP calls the system clock again to obtain the current time in seconds and calculates and displays the execution time in CP seconds in the dayfile together with the number of source blocks processed and the message "GENTOP RUN COMPLETE."

5.3.2 RECOVR and TRECOVR

GENTOP calls the FORTRAN library routine RECOVR to initialize the system reprieve capability in case the program terminates abnormally. GENTOP passes three parameters to RECOVR. The first, TRECOVR, is the address of the user routine to be executed if any of the flagged conditions occur. The second, 77B, is the octal value for the conditions that will select recovery processing. In this case, subroutine TRECOVR will be called if an arithmetic mode error, a PP call error, or an auto-recall error occurs, if a time or storage limit is exceeded, or if an operator drop or kill, a system abort, or a CP abort is detected. The third, LOCF(CHKSUM), is the last address of the recovery code to be checksummed to insure memory integrity before transferring control to the recovery routine. If one of the selected conditions occurs during program execution, the system automatically increases any of the time or storage limits that have been exceeded to allow processing to continue and calls the routine TRECOVR with three parameters. The first, IXCHNG, is a 17-word integer array containing an image of the exchange package and the contents of RA+1. The second, IFLAG, is a flag which instructs the system to process the error condition normally once TRECOVR has terminated. The third, IFLDLN, is the address of RA+1, the start of the user's field length. The system reprieve capability is used in GENTOP to save the current state of the program's global variables on file STOREC together with all of the TOPOG data blocks that have been completely processed during the run. This allows the user to restart GENTOP at approximately the same point in the processing without having to redo a large amount of the calculation to produce a finished TOPOG tape. The user should ensure that his job control deck provides for saving the file STOREC in case of an abnormal exit condition. TRECOVR accomplishes this goal by writing the contents of the common block /GLOBAL/ on

STOREC and then closing the file. The restart option of GENTOP may then be used to open STOREC and read the contents of /GLOBAL/. GENTOP may not be restarted unless the aborted run had completed processing the input data. The flag IRESTRT is used to determine which suboverlay was being executed when the recovery call to TRECOVR was made. If IRESTRT=0, then the input overlay was executing and since no recovery is possible, TRECOVR will close the file STOREC without adding the contents of /GLOBAL/ and issue dayfile messages informing the user that no restart is possible. If IRESTRT=1 or 2, then the process or output overlays were executing and TRECOVR will save the information needed and inform the user that a restart run should be submitted.

5.3.3 HEADER

HEADER is called by all routines that print formatted output to control pagination on the output listing. It counts the number of lines that have been printed, and titles new pages as they are needed. It prints two header lines on each page, giving the GENTOP run title, the date and time of the run, and the page number. HEADER is called with one parameter, NLINES, which specifies the number of lines to be printed in a contiguous group. If this number is greater than the number of lines left on the current page, a page eject will be issued and the header lines printed so that the group of lines will not be split across the page boundary. A new page may be requested by setting NLINES to -1. The local variable, MAXL, is initialized to allow 60 lines per page.

5.3.4 LOADRY

LOADRY is called from GENTOP to request the TOPOG directory file TOPDRY. It stores the volume serial number for the tape (TG0000) and the processing options (9-track, 1600 bpi, I format, PO=WA, and unlabelled) in words 8 and 9 of the FIT for the TOPDRY file. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

5.3.5 LBLRQST

LBLRQST is a COMPASS routine called from LOADRY to request the directory tape, LDTAPE to request the desired DMA standard tapes, and LDTOPOG to request the TOPOG output tape. It has one parameter, IFET, which is an array containing the FET for the file. Notice that the FIT and FET addresses are the same since the FET is actually the initial part of the FIT. The proper options and tape VSN have been stored in the FET before LBLRQST is called. The LABEL (NOS) or REQUEST (NOS/BE) macro is used to make the tape request.

5.3.6 DXSRC/DXREG

DXSRC is the main entry point to this routine which also contains the entry point DXREG. These are the exit addresses supplied to Record Manager to be used to handle end-of-data conditions on the files SOURCE and TOPDRY/REGDRY respectively. The common block /FLAGS/ is used to communicate the end-of-data condition to the program reading the file by setting the appropriate file status flag negative.

5.3.7 EXSRC/EXREG

EXSRC is the main entry point to this routine which also contains the entry point EXREG. These are the exit addresses supplied to Record Manager to be used to handle error conditions on the files SOURCE and TOPDRY/REGDRY respectively. The common block /FLAGS/ is used to communicate an error condition to the program reading the file by setting the appropriate file status flag greater than zero.

5.3.8 INPUT

INPUT is the main program of the (1,0) overlay. It controls the reading and processing of the input data cards. INPUT initially reads the GENTOP run title and gets the date and time from the system clock. INPUT then calls NXTVAR to return the next keyword from the input data card, determines which type of data are to be read, and branches to the section that handles that type. If the restart option has been selected, the random access MSIO file STOREC will contain the contents of the common block /GLOBAL/ that were saved by TRECOVR in the initial run. The common block values are restored from the file STOREC which properly sets the flag IRESTRT to determine where the processing should be continued. The keywords TLATS and TLON are used to enter the latitude/longitude of the southwest corner of the TOPOG data area to be processed. The latitude and longitude must be entered in decimal degrees together with the direction code. The keyword NREG is used to specify the number of regions in the TOPOG tape area. TVSN is used to input the VSN for the TOPOG tape to be generated. NSA gives the number of source areas per source row, and SORCE gives the category code and number of source blocks for each source area in the TOPOG tape area. The ocean blocks to be specified for this run are entered with the keyword OCEAN. All values entered are checked for legal ranges as well as syntax errors. When all of the input data cards have been processed, INPUT will compute the location dependent parameters for this TOPOG tape area and check the NEW/REPLACE status of the TOPOG tape to be generated. The regions around this TOPOG area are also checked to insure that the TOPOG tape area specified is a legal area. The ocean block data are then converted into a bit map of the tape area stored in array IOCEAN. Finally the array SALONE is generated containing the east boundary longitudes of the source areas. INPUT then calls PRSUM to print the input data summary.

5.3.9 NXTVAR

NXTVAR is called from INPUT to crack the free-format input data cards into fields of alphanumeric keywords and floating point numeric values that are returned for processing. Successive cards are read until the end-of-file is encountered. Each card is printed when it is read so that error messages pertaining to that data card will immediately follow the printed card image. On each call to NXTVAR, the next alpha or numeric value along with the following delimiter is returned. If the variable read is not of the type requested (alpha or numeric), an error message will be printed and the error flag will be set. All 80 columns of the data card will be processed. Blanks are ignored. The five characters =./() are recognized as delimiters. The first non-numeric character following a numeric field is also considered a delimiter. Integer values are returned as floating point numbers. If a syntax error is encountered, the rest of the card is skipped. Input values may not span card boundaries. NXTVAR has one parameter, ITYPE, which gives the type of the field expected (1=keyword, 2=number, 3=delimiter, 4=alpha). The value of the decoded field is returned in the variables IVAR (in A10 format) and XNUM (floating point number or -1.0 in the case of a null field followed by a right parenthesis or a comma. It also returns IDEL (the delimiter found as one of the characters =,/() in A1 format or -1 to signify end-of-card), and IERR (0=ok, 1=error found by NXTVAR, -1=error found by the calling routine, or 99=end-of-file on input file) the error flag. These variables are found in common block /NXTVAR/.

5.3.10 DMS

DMS is called from PRSUM to convert a latitude/longitude pair in decimal degrees north and east to a Hollerith encoded format ready to print in positive degrees/minutes/seconds and decimal degrees with the proper direction N, S, E, or W. DMS has four parameters. The first, ZLAT, is the latitude input in decimal degrees north, and the second, ZLON, is the longitude input in decimal degrees east. The third, IDMS, is an array in which the positive degrees/minutes/seconds and direction of the latitude/longitude pair is returned in Hollerith format. The fourth parameter, IDEC, is an array in which the positive decimal degrees and direction of the latitude/longitude pair is returned in Hollerith format.

5.3.11 PRSUM

PRSUM is called from INPUT to print the TOPOG input data summary. It calls HEADER to control pagination of the output listing and DMS to convert latitude/longitude pairs into Hollerith formats suitable for printing in degrees/minutes/seconds and also decimal degrees. The TOPOG input data summary will not be printed if errors were found in the input data. It is intended to give the user a summary of the data values used in the TOPOG run that generated a particular tape. The information printed includes whether this is an initial or restart run, the latitude and longitude of the southwest corner of the TOPOG tape area, the number of regions in the TOPOG tape area, the vsn of the TOPOG output tape being created, the number of source areas per row, and the category code and vsn and file number for each of the source areas. PRSUM also prints a summary of the ocean blocks that were specified for this run. All of these input data values are printed from the information stored in common block /GLOBAL/ during INPUT.

5.3.12 PROCESS

PROCESS is the main program of the (2,0) overlay. It controls the generation of TOPOG data blocks from the DMA standard source tapes. It creates the FIT for the word addressable file, SRCDSK, that is accessed through record manager and opens the file. If the restart option has been specified, the TOPOG data blocks that were generated in the previous run are present on the file STOREC and do not need to be recreated. PROCESS checks the row and column indices of the last district and block completed to determine where to continue processing terrain elevation data. Because the DMA Source tapes have the terrain elevation values stored as a set of files in south-north/west-east column major order, it is most efficient to process the data records sequentially if possible. To accomplish this, PROCESS works through the TOPOG tape area by district and through each district by columns of TOPOG blocks. The data for each source area is stored by column with 1201 elevation values in each record and 1201 records in each file. By copying 151 records to the word addressable disk file, SRCDSK, it is possible to extract a series of matrices of 151 x 151 elevation values that correspond to the grid points of the eight TOPOG blocks in that column. PROCESS calls XTRACT to read the proper records from the DMA Source tape, unpack them to CDC 60-bit integers, and store them on SRCDSK. It then calls ZMATRX to retrieve the proper matrix of terrain elevation data for the TOPOG block being processed. GENREC creates a TOPOG block data record for the block which is temporarily written on file STOREC. PROCESS determines which DMA tape and file should be used for each district from the user-input data and calls LDTAPE and LABDAT to request the tape, position it to the proper file, and read the labels. Source areas may also be declared ocean or missing. A directory is built containing the index and length of the block data record on STOREC or a code indicating that the block is ocean or missing. The directory is written to STOREC to be used in OUTPUT to generate the TOPOG tape.

5.3.13 LDTAPE

LDTAPE is called from PROCESS to request the desired DMA source tapes and check the volume header label to ensure that the proper tape was mounted. LDTAPE has one parameter, IVSN, which is the volume serial number of the desired DMA tape. LDTAPE initializes the File Information Table for file SOURCE and then stores the volume serial number of the DMA tape to be requested and the processing options (9-track, 1600 bpi, Stranger tape format, PO=RA, and unlabeled (NOS) or non-standard labels (NOS/BE)) in words 8 and 9 of the FIT. It then calls the COMPASS routine LBLRQST actually to issue the tape request. LDTAPE then opens and rewinds the file SOURCE. Since the DMA standard tapes contain pseudo-ANSI labels which do not conform to the ANSI standard in all fields, the tapes cannot be read as labeled tapes or the system will reject the labels as being in error. Consequently, the labels must be read as data records and CNVRT is called to unpack the ASCII characters and convert them to CDC display code. LDTAPE reads the VOL1 header label and checks the tape VSN against the VSN that was requested to ensure that the proper tape was mounted.

5.3.14 LABDAT

LABDAT is called from PROCESS to position DMA source tapes to the requested file, read the pseudo-ANSI standard user header label, and extract the source block parameters from the user header label. LABDAT has nine parameters. The first, IVSN, is the vsn of the DMA source tape which is printed with any error messages that may be generated. The second, IFILE, is the sequence number of the requested source file. FLSKIP is called to position the tape to the desired file. The third and fourth parameters, LATS and LONW, are the latitude and longitude of the southwest corner of the desired source block in the format DDDMMSSX where D, M, S denote the alphanumeric degrees, minutes, and seconds, and X is N, S, E, or W. Leading zeros are used where necessary to fill the various fields. The fifth and sixth parameters, LATGIN and LONGIN, are the latitude and longitude grid intervals for the source block in tenths of a second. The seventh and eighth parameters, LATKNT and LONKNT, are the latitude and longitude dimensions of the source block in the number of grid intervals specified by LATGIN and LONGIN. ISTATUS, the ninth parameter, is the error flag (0=ok, else error) returned from OPEN. Parameters LATS, LONW, LATGIN, LONGIN, LATKNT, and LONKNT are all extracted from the user header label for the desired file and returned to PROCESS.

5.3.15 CNVRT

CNVRT is called from LABDAT to convert DMA data labels from ASCII to display code characters. This conversion is necessary because the labels are read as binary data records rather than being processed and converted into display code by the system.

5.3.16 XTRACT

XTRACT is called from PROCESS to read the packed terrain elevation data from the DMA standard source tape that has been positioned to the desired file. It reads 1201 packed 16 bit integer values corresponding to one south-north column of data for the 1° x 1° source block for eight TOPOG blocks. It calls subroutine READ to transfer the packed data from the DMA tape file SOURCE into the array IPSRC. Next XTRACT calls subroutine UNPACK to convert the packed data into 60 bit CDC integers and store the 1201 values in array IUSRC. These unpacked data are then written to the word addressable file SRCDSK by a Record Manager PUT call. XTRACT puts the 151 columns of source data corresponding to eight vertical TOPOG blocks on SRCDSK in one call. If the eight blocks are interior to a source block, the last column read for the previous eight blocks becomes the first column of the next eight blocks since the boundaries overlap by one column. The word addressable file SRCDSK is used to rearrange the order of the source data. The data will be processed as north-south columns of a TOPOG block which will use only 151 values of the 1201 in each column at a time. The desired section is easily read into memory from the word addressable file as needed. XTRACT has three parameters. The first, BLONW, is the west boundary latitude of the TOPOG block column in decimal degrees east for which data are to be extracted from the source file. The second, NGRINT, is the number of source longitude grid intervals that exactly span the TOPOG block column. The third, IFLAG, is the fatal error flag (0=ok, 1=error).

5.3.17 ZMATRX

ZMATRX is called from PROCESS to retrieve the unpacked terrain elevation data stored on file SRCDSK for a particular TOPOG data block. It generates a 151 x 151 array of terrain elevation values at the grid points of a particular TOPOG block stored in array IZMAT in common block /ZDATA/. If the longitude grid interval for the source data differs from that for the TOPOG block, ZMATRX uses linear interpolation in the longitudinal direction to estimate elevations at the TOPOG grid points. ZMATRX has three parameters. The first, IBR, is the TOPOG block row index of the desired block. The second, GLOINS, is the source longitude grid interval in seconds, and the third, GLOINT, is the TOPOG longitude grid interval in seconds. The desired data values are read from the word addressable file SRCDSK with a Record Manager GET call. The proper block of 151 x 151 terrain elevation values is extracted from the 151 columns of 1201 data values on SRCDSK by computing the offset in each data record corresponding to the location of the desired TOPOG block in the column.

5.3.18 GENREC

GENREC is called from PROCESS to generate a TOPOG data block from the 151 x 151 array of source terrain elevations in ZMATRX. GENREC has four parameters. The first two, BLATS and BLONW, are the latitude and longitude of the southwest corner of the TOPOG block in decimal degrees north and west. The third parameter, KODE, is the modified block category code returned from GENREC (-1=missing data, 0=ocean block, n=length of TOPOG block generated). The fourth, IFLAG, is the fatal error flag (0=ok, 1=error found). GENREC scans the terrain elevation values in ZMATRX to determine the minimum and maximum values and count the number of missing, interior, and ocean grid points in the block. The elevation data are then offset by the minimum elevation of the block and packed into the TOPOG block format in the minimum number of bits required to store the relief of the area. Block parameters are stored at the beginning of the TOPOG data block contained in the array IBKDAT in common block /ZDATA/.

5.3.19 FLSKIP

FLSKIP is a COMPASS routine called from LABDAT to position the DMA source tape to the desired file. It uses the Record Manager skip macro SKIPFF which requires IOTEXT to be specifed when the routine is assembled or compiled. FLSKIP has two parameters. The first is the address of the FET for the source file and the second is the number of files to be skipped.

5.3.20 UNPACK

UNPACK is a COMPASS routine called from XTRACT to unpack terrain elevation values from the 16-bit format used on the DMA standard tapes to 60-bit CDC integers. UNPACK has three parameters. The first, IPSREC, is an array containing 1201 packed terrain elevation values corresponding to a north-south column of the DMA 1° x 1° source block. This is equivalent to a north-south column of 8 TOPOG blocks. The second parameter, N, is the number of CDC words in IPSREC. The third, IUSREC, is an array in which the 1201 unpacked CDC integer values are stored. The heart of UNPACK is an instack loop which does the bit manipulation required to extract consecutive 16-bit values from the input array and store them in the output array.

5.3.21 OUTPUT

OUTPUT is the main program of the (3,0) overlay. It generates the completed TOPOG tape and prints summary information to the user. OUTPUT creates the TOPOG preface record and writes it on the TOPOG tape. It also revises the block directory records and writes them together with the TOPOG block data records from file STOREC to the TOPOG tape. OUTPUT also prints a summary of the category codes (complete, partial, ocean, or missing) for each block of the region covered by the TOPOG tape and updates the TOPOG directory file REGDRY.

5.3.22 LDTOPOG

LDTOPOG is called from OUTPUT to request the desired TOPOG tape. It stores the volume serial number for the TOPOG tape to be requested and the processing options (9-track, 1600 bpi, I format, PO=WA, and unlabelled) in words 8 and 9 of the File Information Table for the TOPOG file. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

6. BOXTOP AUXILIARY DISK FILE GENERATION: PROGRAM GENBOX

6.1 Introduction

Because of the large volume of data contained in the TOPOG data base, program GENBOX has been provided to extract the terrain elevation values for a user-defined area and store them on the random-access file BOXTOP. This allows the user to avoid having to request several tapes when the area being referenced includes portions of adjoining TOPOG tape areas. By using program GENBOX, the user can define an area of up to 100 districts to be extracted from the TOPOG tapes and stored on a word-addressable disk file. GENBOX builds directories for file BOXTOP which make data retrieval more efficient. The profile extraction routines, PTOPOG and ZTOPOG, are written to access the BOXTOP disk files.

of CDC words in IPSREC. The third, IUSREC, is an array in which the 1201 unpacked CDC integer values are stored. The heart of UNPACK is an instack loop which does the bit manipulation required to extract consecutive 16-bit values from the input array and store them in the output array.

5.3.21 OUTPUT

OUTPUT is the main program of the (3,0) overlay. It generates the completed TOPOG tape and prints summary information to the user. OUTPUT creates the TOPOG preface record and writes it on the TOPOG tape. It also revises the block directory records and writes them together with the TOPOG block data records from file STOREC to the TOPOG tape. OUTPUT also prints a summary of the category codes (complete, partial, ocean, or missing) for each block of the region covered by the TOPOG tape and updates the TOPOG directory file REGDRY.

5.3.22 LDTOPOG

LDTOPOG is called from OUTPUT to request the desired TOPOG tape. It stores the volume serial number for the TOPOG tape to be requested and the processing options (9-track, 1600 bpi, I format, PO=WA, and unlabelled) in words 8 and 9 of the File Information Table for the TOPOG file. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

6. BOXTOP AUXILIARY DISK FILE GENERATION: PROGRAM GENBOX

6.1 Introduction

Because of the large volume of data contained in the TOPOG data base, program GENBOX has been provided to extract the terrain elevation values for a user-defined area and store them on the random-access file BOXTOP. This allows the user to avoid having to request several tapes when the area being referenced includes portions of adjoining TOPOG tape areas. By using program GENBOX, the user can define an area of up to 100 districts to be extracted from the TOPOG tapes and stored on a word-addressable disk file. GENBOX builds directories for file BOXTOP which make data retrieval more efficient. The profile extraction routines, PTOPOG and ZTOPOG, are written to access the BOXTOP disk files.

6.2 User's Guide to GENBOX

6.2.1 Overview

GENBOX is the first step to using the TOPOG data base. Since accessing the tapes directly is inefficient, it is recommended that the user create one or more BOXTOP disk files for the areas to be referenced. GENBOX is easy to use and requires very little user-input data. The user simply enters the boundaries of the area to be extracted to disk and the name of the area. GENBOX determines the actual boundaries of the area to coincide with enclosing district boundaries. It requests the necessary TOPOG tapes and copies the block data records for all blocks in the area to BOXTOP. GENBOX builds a two-level directory to the word-addressable file to facilitate data retrieval. The district directory contains the starting word address of the block directory record for each district. The block directory records then contain the starting word address and length of the block data record for each block in the appropriate district. The BOXTOP file structure is described in Section 3.3. The input/output for a sample GENBOX run is described in Section 6.2.4.

6.2.2 GENBOX Input Data

The following input data values are required for a GENBOX run. Each item is entered on a separate card. Blanks are ignored. The data values may be entered in any order except the title which must be the first card.

(1) Title card

The first card in the input deck is assumed to be the title card. Up to 80 characters of title information may be entered. The title is printed on every page of output with the date and time to identify the job uniquely.

(2) NAME

The keyword NAME is used to enter a 20 character name for the area being extracted to the BOXTOP disk file. The name is entered as NAME = area name.

(3) ULATN

The north boundary latitude of the user-defined area is entered in positive degrees, minutes, and seconds with a direction code as ULATN = (dd,mm,ss,D). The degrees must be within the range 0 to 90. The legal direction codes are N and S.

(4) ULATS

The south boundary latitude of the user defined area is entered in positive degrees, minutes, and seconds with a direction code as ULATS = (dd,mm,ss,D). The degrees must be within the range 0 to 90. The legal direction codes are N and S.

(5) ULONE

The east boundary longitude of the user defined area is entered in positive degrees, minutes and seconds with a direction code as ULONE = (ddd,mm,ss,D). The degrees must be within the range 0 to 180. The legal direction codes are E and W.

(6) ULONW

The west boundary longitude of the user defined area is entered in positive degrees, minutes and seconds with a direction code as ULONW = (ddd,mm,ss,D). The degrees must be within the range 0 to 180 and the minutes and seconds must be within the range 0 to 60. The legal direction codes are E and W.

6.2.3 Job Control Language

The control card sequence for a GENBOX run is shown in Table 6-1. Aside from attaching and executing the program, there is only one required control card. The BOXTOP file to be created must be a permanent file. Since it may be a very large file, it should be defined as a direct-access file under NOS, or requested as a permanent file under NOS/BE before GENBOX is executed.

6.2.4 Sample GENBOX Input/Output

Figure 6-1 shows a sample GENBOX run which created a BOXTOP file containing terrain elevation data for the WALLOWA region of the Pacific

Table 6-1. GENBOX Input Data Deck for Generating File BOXTOP

```
PSJP,T177.
USER(EMCAD)
CHARGE,910,910xxxx.
GET,GENBOX.
DEFINE,BOXTOP.
GENBOX.
/EOR    {end-of-record}
GENBOX TEST RUN.
NAME=WALLOWA TEST
ULATS=(44,35,10,N)
ULATN=(45,50,00,N)
ULONW=(118,45,30,W)
ULONE=(116,32,30,W)
/EOF    {end-of-file}
```

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION                80/07/11.   16.43.57.        PAGE      1
GENBOX TEST RUN.

                GENBOX TEST RUN.

                NAME=WALLOWA TEST

                ULATS=(44,35,10,N)

                ULATN=(45,50,00,N)

                ULONW=(118,45,30,W)

                ULONE=(116,32,20,W)

     END OF INPUT DATA CARDS
```

Figure 6-1. GENBOX output for Wallowa BOXTOP file creation.

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION          80/07/11.   16.43.57.     PAGE    2
GENBOX TEST RUN.

GENBOX INPUT DATA SUMMARY
*************************

TITLE:  GENBOX TEST RUN.

NAME:  WALLOWA TEST

LATITUDE OF NORTH BOUNDARY OF BOXTOP DISK AREA (ULATN):  ( 45,50,00,N)     ( 45.83,N)

LATITUDE OF SOUTH BOUNDARY OF BOXTOP DISK AREA (ULATS):  ( 44,35,10,N)     ( 44.59,N)

LONGITUDE OF WEST BOUNDARY OF BOXTOP DISK AREA (ULONW):  (116,45,30,W)     (116.76,W)

LONGITUDE OF EAST BOUNDARY OF BOXTOP DISK AREA (ULONE):  (116,32,20,W)     (116.54,W)
```

Figure 6-1.   (Continued).

```
TTTTTTTTT   OOOOOOOOO   PPPPPPPPP   OOOOOOOOO   GGGGGGGGG
    T       O       O   P       P   O       O   G
    T       O       O   P       P   O       O   G
    T       O       O   P       P   O       O   G
    T       O       O   PPPPPPPPP   O       O   G    GGGGG
    T       O       O   P           O       O   G        G
    T       O       O   P           O       O   G        G
    T       OOOOOOOOO   P           OOOOOOOOO   GGGGGGGGG
```

DIGITAL TERRAIN ELEVATION DATA

```
* * * * * * * * * * * * * * * * * *
*                                 *
*                                 *
*         BOXTOP DISK FILE        *
*                                 *
*                                 *
* * * * * * * * * * * * * * * * * *
```

DISK AREA NAME WALLOWA TEST

DISK AREA BOUNDARIES 44 N - 46 N
119 W - 116 W

DATE GENERATED 80/07/11.

ORGANIZATION ID NTIA/ITS

Figure 6-1. (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION          80/07/11.   16.43.57.       PAGE
GENBOX TEST RUN.


                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATICN DATA

              BCXTOP DISK AREA  WALLCWA TEST                                    DISTRICT    1

      119 00 W        118 30 W        118 00 W
          *               *               *
45 00 N * * * * * * * * * * * * * * * * * * * 45 00 N
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
44 30 N * * * * * * * * * * * * * * * * * * * 44 30 N
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
          * * * * * * * * * * * * * * * * *
          *   *   *   *   *   *   *   *   *
          * M * M * M * M * M * M * M * M *
          *   *   *   *   *   *   *   *   *
44 00 N * * * * * * * * * * * * * * * * * * * 44 00 N
          *               *               *
      119 00 W        118 30 W        118 00 W

     ( DATA STATUS SYMBOLS     C = COMPLETE    P = PARTIAL    O = OCEAN    M = MISSING )
```

Figure 6-1. (Continued).

```
                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

          BOXTOP DISK AREA   WALLOWA TEST                                    DISTRICT   2

                         118 00 W          117 30 W          117 00 W
                            *                 *                 *
               45 00 N  * * * * * * * * * * * * * * * * * * *  45 00 N
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
               44 30 N  * * * * * * * * * * * * * * * * * * *  44 30 N
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
                          * * * * * * * * * * * * * * * * *
                          *   *   *   *   *   *   *   *   *
                          * M * M * M * M * M * M * M * M *
                          *   *   *   *   *   *   *   *   *
               44 00 N  * * * * * * * * * * * * * * * * * * *  44 00 N
                            *                 *                 *
                         118 00 W          117 30 W          117 00 W

          ( DATA STATUS SYMBOLS     C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING )
```

Figure 6-1. (Continued).

TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION   80/07/11.   16.43.57.   PAGE   6
GENBOX TEST RUN.

```
                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATICN DATA

          BOXTOP DISK AREA   WALLOWA TEST                                        DISTRICT    3

                           117 00 W           116 30 W           116 00 W
                               *                  *                  *
               45 00 N   * * * * * * * * * * * * * * * * * * *   45 00 N
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
               44 30 N   * * * * * * * * * * * * * * * * * * *   44 30 N
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
                           * * * * * * * * * * * * * * * * *
                           *   *   *   *   *   *   *   *   *
                           * M * M * M * M * M * M * M * M *
                           *   *   *   *   *   *   *   *   *
               44 00 N   * * * * * * * * * * * * * * * * * * *   44 00 N
                               *                  *                  *
                           117 00 W           116 30 W           116 00 W

          ( DATA STATUS SYMBCLS     C = COMPLETE    P = PARTIAL    O = OCEAN    M = MISSING )
```

Figure 6-1. (Continued).

```
                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

            BOXTOP DISK AREA  WALLOWA TEST                                          DISTRICT    4
                               119 00 W         118 30 W         118 00 W
                                  *                *                *
                   46 00 N  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  46 00 N
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                   45 30 N  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  45 30 N
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                                  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *
                                  *     *     *    *     *     *     *     *    *
                                  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *  C  *
                                  *     *     *    *     *     *     *     *    *
                   45 00 N  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  45 00 N
                                  *                *                *
                               119 00 W         118 30 W         118 00 W

            ( DATA STATUS SYMBOLS     C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING )
```

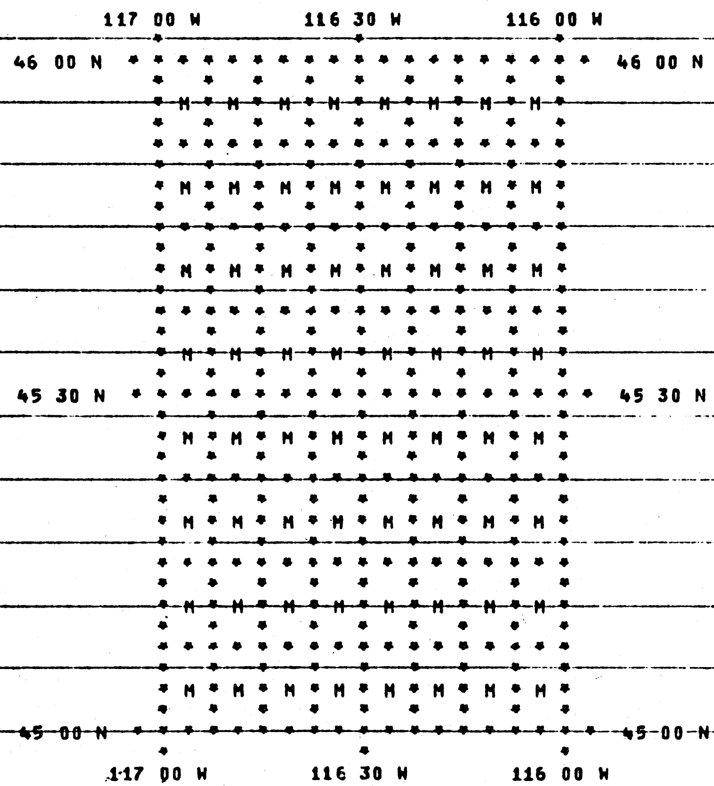
Figure 6-1 . (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION                    80/07/11.   16.43.57.       PAGE     8
GENBOX TEST RUN.


                          BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATICN DATA

                BOXTOP DISK AREA  WALLCWA TEST                                        DISTRICT     5

                              118 00 W        117 30 W        117 00 W
                                  *               *               *
                       46 00 N  * * * * * * * * * * * * * * * * * *  * 46 00 N
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                       45 30 N  * * * * * * * * * * * * * * * * * *  * 45 30 N
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                                  * * * * * * * * * * * * * * * * *
                                  *   *   *   *   *   *   *   *   *
                                  * C * C * C * C * C * C * C * C *
                                  *   *   *   *   *   *   *   *   *
                       45 00 N  * * * * * * * * * * * * * * * * * *  * 45 00 N
                                  *               *               *
                              118 00 W        117 30 W        117 00 W

                ( DATA STATUS SYMBOLS     C = COMPLETE    P = PARTIAL    O = OCEAN    M = MISSING )
```

Figure 6-1. (Continued).

BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

BOXTOP DISK AREA WALLOWA TEST DISTRICT 6



(DATA STATUS SYMBOLS C = COMPLETE P = PARTIAL O = OCEAN M = MISSING)

Figure 6-1. (Continued).

```
ADLYUCH. 80/07/11.N O A A / E R L   6600B  80/06/27.

16.43.08.PSJP,T177.
16.43.08.USER(ENCAD)
15.43.09.CHARGE(910,176P327)
16.43.32.GET,GENBOX.
16.43.48.RESOURC,NT=2.
16.43.48.PURGE,BOXTOP.
16.43.49.DEFINE,BOXTOP.
16.43.51.GET,TESTGEN.
16.43.52.GENBOX,TESTGEN.
16.43.53.*BOXTOP GENERATION*
20.09.54.NT65, ASSIGNED TO TOPDRY , VSN=TG0000.
20.21.19.NT61, ASSIGNED TO TOPOG  , VSN=TG2631.
20.23.13.NT,C07-0-01,TG2631,FD,  ,S0,GS41017520.
20.23.13.NT,C07,D000014000000000004001000000002700
20.23.13.NT,C07,U404600000001013200000005,T4000.
20.23.13.NT,C07,F0 ,I00,B001147,L5004,P00000000.
20.23.13.NT,C07,E25,H42616646, ON THE FLY.
20.23.50.   BOXTOP FILE GENERATED
20.23.50.   EXECUTION TIME IN CP SECONDS =
20.23.50.  8.3249999999993  E+000
20.23.50.*GENBOX RUN COMPLETE*
20.23.50.     STOP
20.23.50.     044100 MAXIMUM EXECUTION FL.
20.23.50.      8.336 CP SECONDS EXECUTION TIME.
20.23.50.LEAD,        0.003KUNS.
20.23.50.UEPF,        0.592KUNS.
20.23.50.UEMT,        3.184KUNS.
20.23.50.UEMS,       72.782KUNS.
20.23.50.UECP,        8.421SECS.
20.23.50.AESR,       21.544UNTS.
20.24.20.UCLP, 8945,      0.704KUNS.
```

Figure 6-1. (Continued).

northwest. Notice that the actual boundaries of the disk area enclose the user-defined area and correspond to district boundaries. The block status map shows that data are missing for some of the area because the TOPOG tape for the region south of TG2631 had not yet been generated. Only one TOPOG tape was used in this example. However, Figure 6-2 shows portions of output from a GENBOX run where three TOPOG tapes were needed to extract the data for the BOXTOP file. The block status map shows ocean blocks as well as complete blocks in this area.

6.3 GENBOX Internal Software Description

The GENBOX software is divided into three overlays consisting of GENBOX - the controlling main overlay, INPUT - which reads and processes data cards, and FILBOX - which extracts topographic data for the desired area from the TOPOG tapes, builds the auxiliary BOXTOP disk file, and prints the summary information. The structure of the overlays is shown in Figures 6-3 through 6-6. Files and common blocks used throughout GENBOX are described in Tables 6-2 and 6-3.

The main (0,0) overlay includes the program GENBOX and subroutines HEADER, DXTOP/DXREG/DXDIR, and EXTOP/EXREG/EXDIR. It controls the execution flow of the program by loading sub-overlays as they are needed. GENBOX issues dayfile messages to inform the user of any errors that may have occurred and the execution time in CP seconds. It also creates the File Information Tables for the files DIRBLK and BOXTOP. DIRBLK is the scratch file used to contain the block directory records for the TOPOG file currently being accessed. BOXTOP is the auxiliary disk file containing the digital terrain elevation data and associated directories for the user-defined area that is being created. These files are opened and closed in GENBOX. The HEADER subroutine controls the pagination of the output listing, and DXTOP/DXREG/DXDIR and EXTOP/EXREG/EXDIR are used to handle end-of-data and error conditions on the three Record Manager files TOPOG, TOPDRY, and DIRBLK.

The (1,0) overlay includes the program INPUT and subroutines NXTVAR, DMS, and PRSUM. INPUT reads and processes the free-format input data cards used to specify the name and boundaries of the auxiliary disk area to be extracted. Each card is printed when it is read, so that diagnostics will follow the card containing the error. If a syntax error is encountered, the rest of the card

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION          80/08/05.   16.09.25.        PAGE     1
GENBOX PACNW FILE EXTRACTION.

                   GENBOX PACNW FILE EXTRACTION.
                   NAME=PUGET SOUND TEST
                   ULATS=(45,0,0,N)
                   ULATN=(50,0,0,N)
                   ULONW=(125,15,0,W)
                   ULONE=(119,50,0,W)
      END OF INPUT DATA CARDS
```

Figure 6-2. GENBOX output for Puget Sound BOXTOP file creation.

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION                80/08/13.   16.09.25.      PAGE   2
GENBOX PACNW FILE EXTRACTION.

GENBOX INPUT DATA SUMMARY
*************************

TITLE:  GENBOX PACNW FILE EXTRACTION.

NAME:  PUGET SOUND TEST

LATITUDE OF NORTH BOUNDARY OF BOXTOP DISK AREA (ULATN):  ( 50,00,00,N)    ( 50.00,N)

LATITUDE OF SOUTH BOUNDARY OF BOXTOP DISK AREA (ULATS):  ( 45,00,00,N)    ( 45.00,N)

LONGITUDE OF WEST BOUNDARY OF BOXTOP DISK AREA (ULONW):  (125,15,00,W)    (125.25,W)

LONGITUDE OF EAST BOUNDARY OF BOXTOP DISK AREA (ULONE):  (119,50,00,W)    (119.83,W)
```

Figure 6-2. (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION          80/08/ 5.   16.09.25.      PAGE    3
GENBOX PACNW FILE EXTRACTION.


                    TTTTTTTTT   000000000   PPPPPPPPP   000000000   GGGGGGGGG
                        T       0       0   P       P   0       0   G
                        T       0       0   P       P   0       0   G
                        T       0       0   P       P   0       0   G
                        T       0       0   PPPPPPPPP   0       0   G    GGGGG
                        T       0       0   P           0       0   G        G
                        T       0       0   P           0       0   G        G
                        T       000000000   P           000000000   GGGGGGGGG

                              DIGITAL TERRAIN ELEVATION DATA

                           * * * * * * * * * * * * * * * * * *
                           *                                 *
                           *                                 *
                           *         BOXTOP DISK FILE        *
                           *                                 *
                           *                                 *
                           * * * * * * * * * * * * * * * * * *

                         DISK AREA NAME            PUGET SOUND TEST

                         DISK AREA BOUNDARIES        45 N  -  50 N
                                                    126 W  -  119 W

                         DATE GENERATED            80/08/05.

                         ORGANIZATION ID           NTIA/ITS
```

Figure 6-2. (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION                80/08/05.   16.09.25.     PAGE
GENBOX PACNW FILE EXTRACTION.

                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

          BOXTOP DISK AREA  PUGET SOUND TEST                                  DISTRICT   1

                     126 00 W        125 30 W        125 00 W
                         *               *               *
               46 00 N * * * * * * * * * * * * * * * * * * *  46 00 N
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
               45 30 N * * * * * * * * * * * * * * * * * * *  45 30 N
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
                         * * * * * * * * * * * * * * * * *
                         *   *   *   *   *   *   *   *   *
                         * O * O * O * O * O * O * O * O *
                         *   *   *   *   *   *   *   *   *
               45 00 N * * * * * * * * * * * * * * * * * * *  45 00 N
                         *               *               *
                     126 00 W        125 30 W        125 00 W

          ( DATA STATUS SYMBOLS    C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING )
```

Figure 6-2. (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION                               80/08/05.   16.09.25.        PAGE     5
GENBOX PACNW FILE EXTRACTION.


                                  BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

                        BOXTOP DISK AREA  PUGET SOUND TEST                                     DISTRICT    2

                                        125 00 W           124 30 W           124 00 W
                                           *                  *                  *
                              46 00 N  * * * * * * * * * * * * * * * * * * *  46 00 N
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                              45 30 N  * * * * * * * * * * * * * * * * * * *  45 30 N
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * C *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * 0 *
                                         *   *   *   *   *   *   *   *   *
                                         * * * * * * * * * * * * * * * * *
                                         *   *   *   *   *   *   *   *   *
                                         * 0 * 0 * 0 * 0 * 0 * 0 * 0 * C *
                                         *   *   *   *   *   *   *   *   *
                              45 00 N  * * * * * * * * * * * * * * * * * * *  45 00 N
                                           *                  *                  *
                                        125 00 W           124 30 W           124 00 W
                        ( DATA STATUS SYMBOLS     C = COMPLETE   P = PARTIAL   O = OCEAN   M = MISSING )
```

Figure 6-2. (Continued).

```
TOPOG TERRAIN ELEVATION DATA - BOXTOP DISK FILE GENERATION          83/08/05.   16.09.25.        PAGE    6
GENBOX PACNW FILE EXTRACTION.


                         BLOCK STATUS MAP FOR TOPOG TERRAIN ELEVATION DATA

               BOXTOP DISK AREA  PUGET SOUND TEST                              DISTRICT    3

                  124 00 W        123 30 W        123 00 W
                     *               *               *
      46 00 N  * * * * * * * * * * * * * * * * * * *  46 00 N
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
      45 30 N  * * * * * * * * * * * * * * * * * * *  45 30 N
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
                 * * * * * * * * * * * * * * * * *
                 *   *   *   *   *   *   *   *   *
                 * C * C * C * C * C * C * C * C *
                 *   *   *   *   *   *   *   *   *
      45 00 N  * * * * * * * * * * * * * * * * * * *  45 00 N
                     *               *               *
                  124 00 W        123 30 W        123 00 W

  ( DATA STATUS SYMBOLS     C = COMPLETE    P = PARTIAL    O = OCEAN    M = MISSING )
```

Figure 6-2. (Continued).

```
ABAYCIK. 80/08/05.N O A A / E R L   6600A  80/07/19.
15.59.19.PSJP,T377.
15.59.19.UCCR, AA41,       0.015KCDS.
15.59.19.USER(EDUTTO)
15.59.19.CHARGE(910,9105105)
15.59.21.RESOURC(NT=1,DJ1=1)

15.59.22.GET(GENBOX/UN=EMCAD)
15.59.31.PURGE(PACNW/PN=DJ22,NA)
16.09.20.DEFINE(BOXTOP=PACNW/PN=DJ22,NA)
16.09.24.GENBOX.
16.09.24.*BOXTOP GENERATION*
17.28.17.NT63, ASSIGNED TO TOPDRY , VSN=TG0000.
19.35.40.NT66, ASSIGNED TO TOPOG  , VSN=TG2628.
20.22.13.NT62, ASSIGNED TO TOPOG  , VSN=TG2630.
20.46.16.NT66, ASSIGNED TO TOPOG  , VSN=TG2631.
20.52.20.
20.52.20.     044600 MAXIMUM EXECUTION FL.
20.52.20.     58.558 CP SECONDS EXECUTION TIME.
20.52.20.UEAD,       0.038KUNS.
20.52.20.UEPF,       0.635KUNS.
20.52.20.UEMT,      33.176KUNS.
20.52.20.UEMS,     561.661KUNS.
20.52.20.UECP,      58.887SECS.
20.52.20.AESR,     187.150UNTS.
20.57.09.UCLP, AA43,       5.312KLNS.
```

Figure 6-2. (Continued).

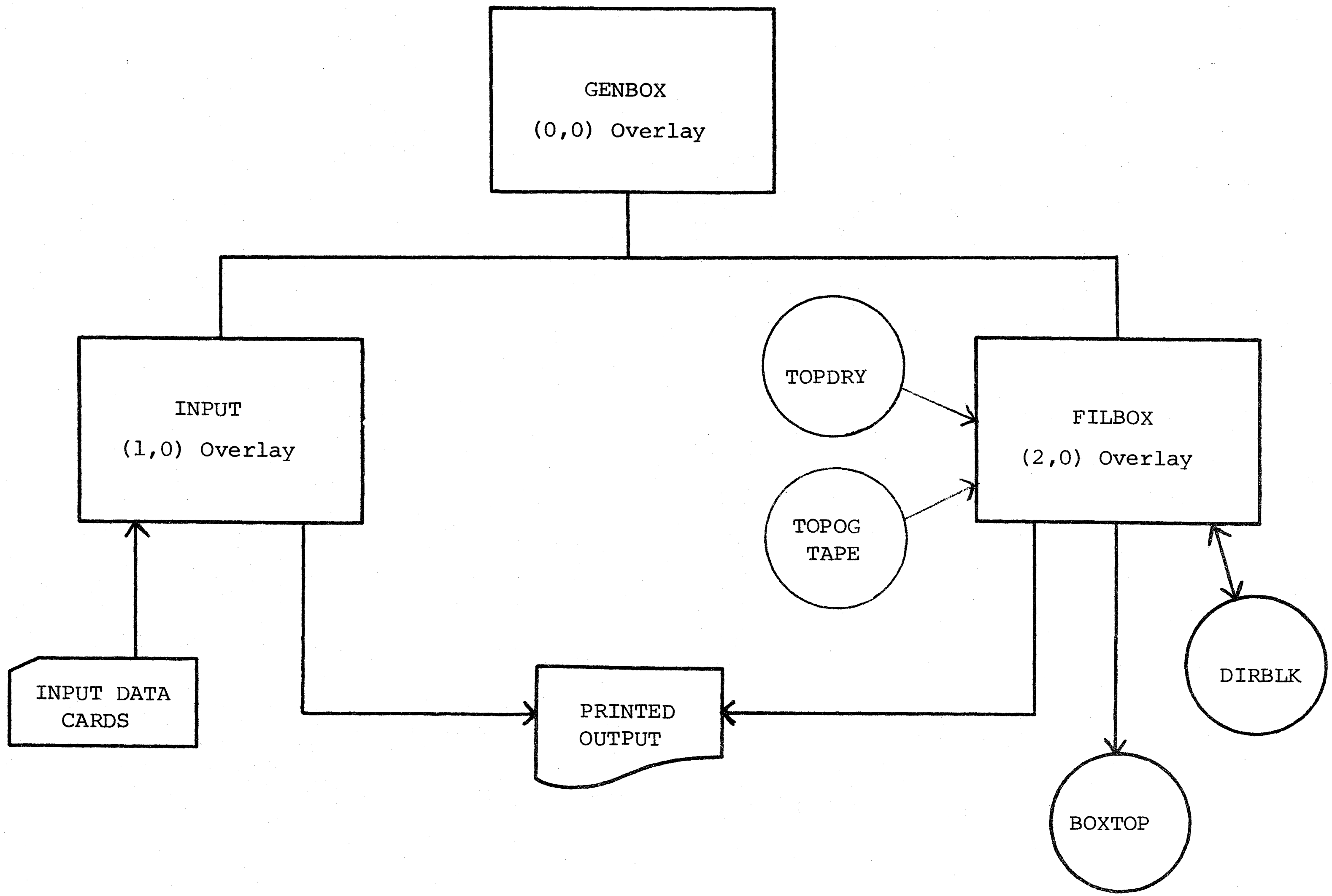


Figure 6-3. GENBOX structure.

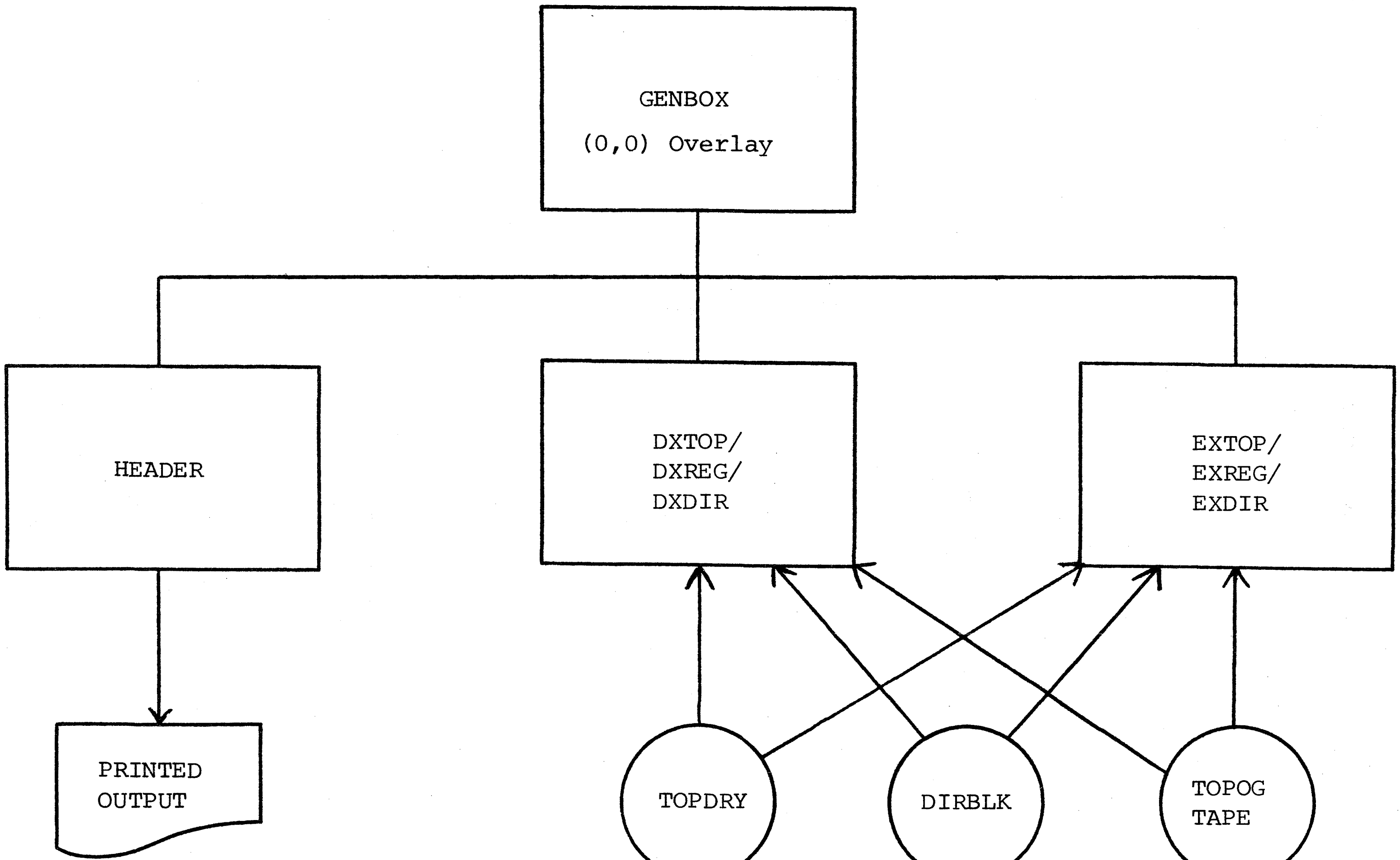


Figure 6-4. GENBOX (0,0) overlay structure.

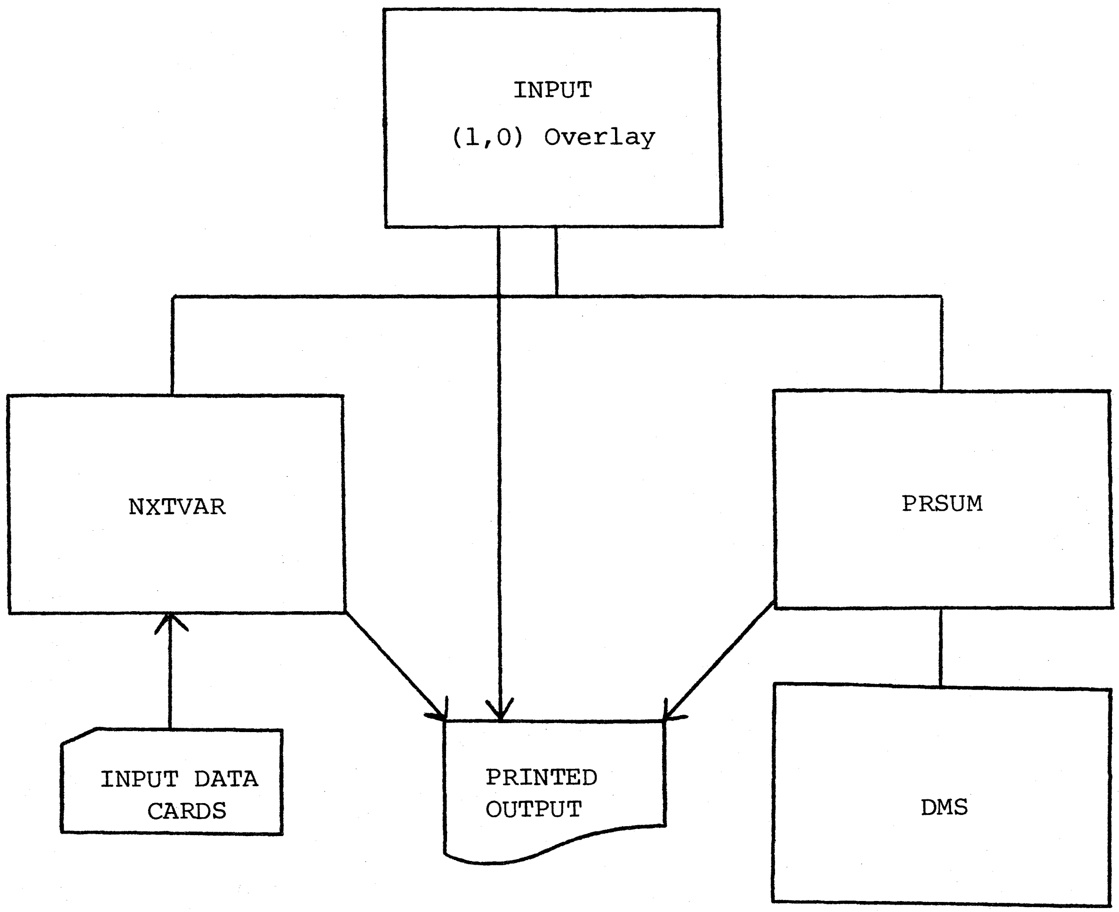


Figure 6-5. INPUT (1,0) overlay structure.

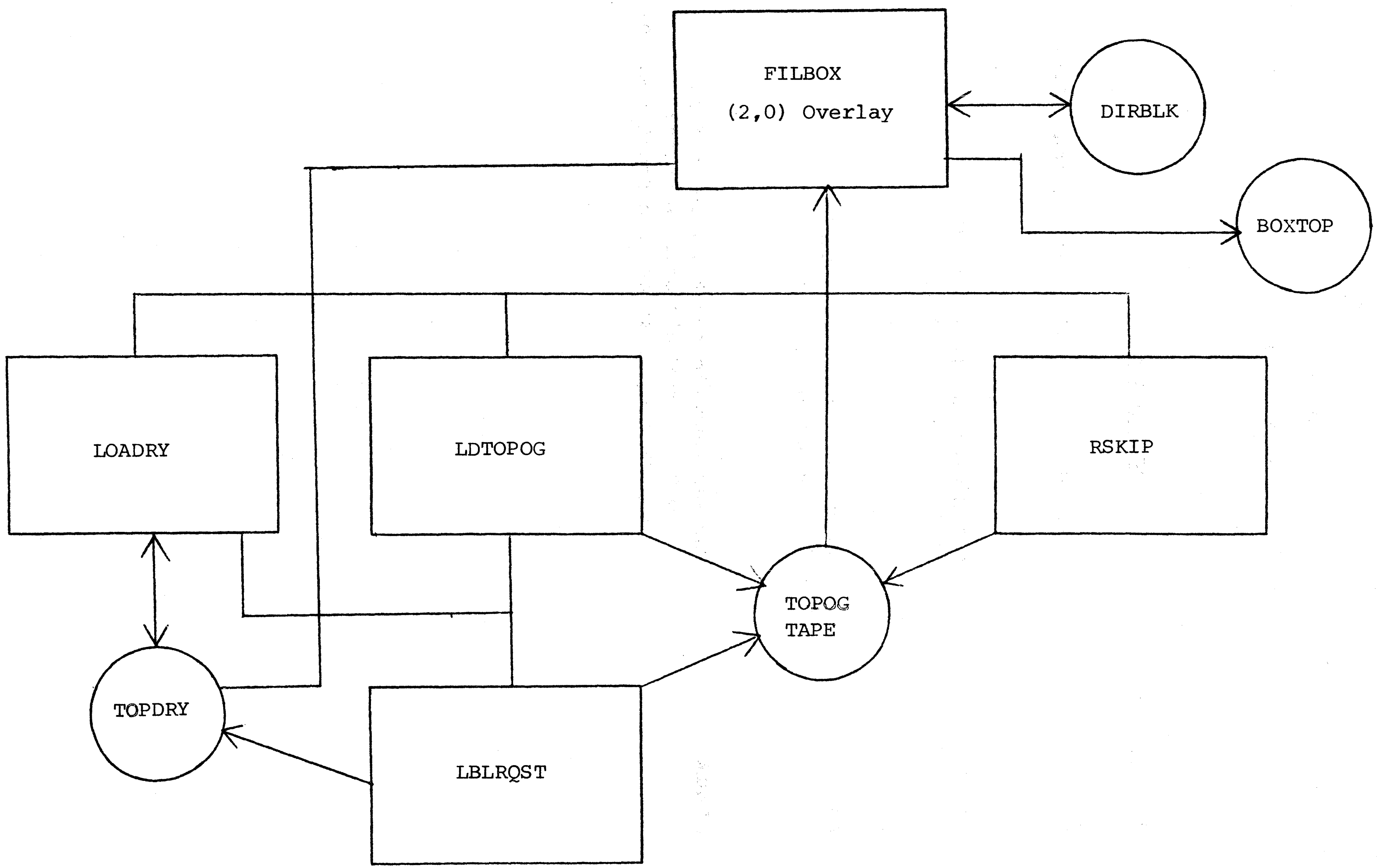


Figure 6-6. FILBOX (2,0) overlay structure.

Table 6-2. GENBOX Files

File Name	Description
TOPDRY	TOPOG directory file (see Section 2.3.5)
TOPOG	TOPOG terrain elevation file (see Section 2.3.1)
BOXTOP	BOXTOP auxiliary disk file (see Section 3.3.2)
DIRBLK	Word-addressable scratch file used to contain TOPOG directories during BOXTOP file creation (see Section 6.2.9)

Table 6-3. GENBOX Common Blocks

Common Block /GLOBAL/

ITITLE	Title of current run (80 characters)
IDATE	Current date (10 characters)
ITIME	Current time (10 characters)
NAME	Name of disk area (area covered by file BOXTOP) (20 characters
ALATS	Actual south boundary latitude of disk area (decimal degrees N)
ALATN	Actual north boundary latitude of disk area (decimal degrees N)
ALONW	Actual west boundary longitude of disk area (decimal degrees E)
ALONE	Actual east boundary longitude of disk area (decimal degrees E)
ULATS	User-input south boundary latitude of disk area (decimal degres N)
ULATN	User-input north boundary latitude of disk area (decimal degrees N)
ULONW	User-input west boundary longitude of disk area (decimal degrees E)
ULONE	User-input east boundary longitude of disk area (decimal degrees E)
LONGIN	Longitude dimension of TOPOG regions in each zone (decimal degrees)
LODINT	Longitude dimension of Districts in each row of districts in disk area (decimal degrees)
ALODIM	Longitude dimension of disk area (decimal degrees
NERR	Number of fatal errors

Table 6-3. (Continued)

Common Block /ZFIT/

IFIT	FIT/FET for file DIRBLK
IBUFF	65 word buffer for file DIRBLK
JFIT	FIT/FET for file BOXTOP
JBUFF	65 word buffer for file BOXTOP
MFIT	FIT/FET for file TOPDRY
MBUFF	65 word buffer for file TOPDRY
NFIT	FIT/FET for file TOPOG
NBUFF	2002 word buffer for file TOPOG

Common Block /FLAGS/

ISTATUS	Status flag for file DIRBLK (0=ok, -1=end-of-data, 1-error)
MSTATUS	Status flag for file TOPDRY (0=ok, -1=end-of-data, 1=error)
NSTATUS	Status flag for file TOPOG (0=ok, -1=end-of-data, 1=error)

Common block /NXTVAR/

IVAR	Alphanumeric field returned as up to 10 characters
XNUM	Numeric Values returned as floating point number or -1 for null field
IDEL	Delimiter returned as one of the characters =,/() or -1 for end of card
IERR	Error flag (0=ok, 1=error found by NXTVAR -1=error found by calling routines, 99=EOF on input file)

will be skipped. Each input value must be given on a separate card. The keywords and their associated option or data values are checked for validity and the proper information is stored in common block /GLOBAL/. Some initialization values are also set that depend on the particular user area to be extracted. Subroutine NXTVAR is used to crack the free-format card into fields, and DMS to convert latitude/longitude values in decimal degrees north and east into a print-ready Hollerith format in positive degrees/minutes/ seconds and decimal degrees together with the proper direction. Subroutine PRSUM prints a summary of the input data values to be used in the GENBOX run.

The (2,0) overlay includes the program FILBOX and subroutines LOADRY, LDTOPOG, LBLRQST, and RSKIP. FILBOX extracts the necessary terrain elevation data to cover the user-defined area from the appropriate TOPOG tape and writes it together with directory information to the disk file BOXTOP. It also prints a summary of the contents of BOXTOP which shows the complete, partial, ocean, and missing blocks contained in the file. Subroutines LOADRY, LDTOPOG, and LBLRQST are used to request the TOPOG tapes and RSKIP is used to position the TOPOG tape to the desired record.

6.3.1 GENBOX

GENBOX is the main program of the (0,0) overlay. It issues the initial message "BOXTOP GENERATION" to the dayfile and calls the system clock to obtain the starting time in seconds. GENBOX then calls the INPUT overlay to read and process the input data cards. If fatal errors were detected by INPUT, GENBOX will display the number of errors in the dayfile and abort the run. Otherwise, GENBOX creates the file information tables for the record manager files DIRBLK, BOXTOP, and REGDRY and opens the files for later use. GENBOX then calls the FILBOX overlay to extract the desired terrain elevation data from the TOPOG tapes and create the BOXTOP auxiliary disk file. When FILBOX finishes processing data, GENBOX closes the three files it opened, and checks for fatal errors. It then either displays the number of errors encountered by FILBOX or issues the message "GENBOX RUN COMPLETE" and displays the execution time in CP seconds in the dayfile.

6.3.2 HEADER

HEADER is called by all routines that print formatted output to control pagination on the output listing. It counts the number of lines that have been printed, and titles new pages as they are needed. It prints two header lines on each page, giving the GENBOX run title, the date and time of the run, and the page number. HEADER is called with one parameter, NLINES, which specifies the number of lines to be printed in a contiguous group. If this number is greater than the number of lines left on the current page, a page eject will be issued and the header lines printed so that the group of lines will not be split across a page boundary. A new page may be requsted by setting NLINES to -1. The local variable MAXL is initialized to allow 60 lines per page.

6.3.3 DXTOP/DXREG/DXDIR

DXTOP is the main entry point to this routine which also contains the entry points DXREG and DXDIR. These are the exit addresses supplied to Record Manager to be used to handle end-of-data conditions on the files TOPOG, TOPDRY, and DIRBLK, respectively. The common block /FLAGS/ is used to communicate the end-of-data condition to the program reading the file by setting the appropriate file status flag negative.

6.3.4 EXTOP/EXREG/EXDIR

EXTOP is the main entry point to this routine which also contains the entry points EXREG and EXDIR. These are the exit addresses supplied to Record Manager to be used to handle error conditions on the files TOPOG, TOPDRY, and DIRBLK, respectively. The common block /FLAGS/ is used to communicate an error condition to the program reading the file by setting the appropriate file status flag greater than zero.

6.3.5 INPUT

INPUT is the main program of the (1,0) overlay. It controls the reading and processing of the input data cards. INPUT initially reads the GENBOX run title and gets the date and time from the system clock. INPUT then calls NXTVAR to return the next keyword from the input data card, determines which type of data are to be read, and branches to the section that handles that type. The keyword NAME is used to enter a 20-character name for the auxiliary file area being extracted. The keywords ULATN, ULATS, ULONE, and ULONW are used to enter the latitude and longitude boundaries for the area to be extracted to the file BOXTOP. The latitude and longitude must be entered in degrees, minutes, and seconds together with the proper direction N, S, E, or W. All values entered are checked for legal ranges as well as syntax errors. When all of the input data cards have been processed, INPUT will calculate the actual boundaries of the BOXTOP auxiliary disk file area to be extracted by expanding the user-defined area to the closest surrounding district boundary. It then checks the number of districts included in the disk area against the maximum limit of 100. Finally, INPUT calls PRSUM to print the input data summary.

6.3.6 NXTVAR

NXTVAR is called from INPUT to crack the free-format input data cards into fields of alphanumeric keywords and floating point numeric values that are returned for processing. Successive cards are read until the end-of-file is encountered. Each card is printed when it is read so that error messages pertaining to that data card will immediately follow the printed card image. On each call to NXTVAR, the next alpha or numeric value along with the following delimiter is returned. If the variable read is not of the type requested (alpha or numeric), an error message will be printed and the error flag will be set. All 80 columns of the data card will be processed. Blanks are ignored. The five characters =,/() are recognized as delimiters. The first non-numeric character following a numeric field is also considered a delimiter. Integer values are returned as floating point numbers. If a syntax error is encountered, the rest of the card is skipped. Input values may not span card boundaries. NXTVAR has one parameter, ITYPE, which gives the type of the field expected (1=keyword, 2=number, 3=delimiter, 4=alpha). The value of the decoded field is returned in the variables IVAR (in A10 format) and XNUM (floating point number or -1.0 in the case of a null field followed by a right parenthesis or a comma. It also returns IDEL (the delimiter found as one of the characters =,/() in A1 format or -1 to signify end-of-card), and IERR (0=ok, 1=error found by NXTVAR, -1=error found by the calling routine, or 99=end-of-file on input file) the error flag. These variables are found in common block /NXTVAR/.

6.3.7 DMS

DMS is called from PRSUM to convert a latitude/longitude value in decimal degrees north and east to a Hollerith encoded format ready to print in positive degrees/minutes/seconds and decimal degrees with the proper direction N, S, E, or W. DMS has four parameters. The first, ZDEG, is the latitude or longitude in decimal degrees north or east. The second, ITYPE, is 1) to indicate that ZDEG represents a latitude, and 2) for a longitude value. The third, IDMS, is the array that will contain the Hollerith format of the latitude or longitude in positive degrees/minutes/seconds with the proper direction. The fourth, IDEC, is the array that will contain the Hollerith format of the latitude or longitude in positive decimal degrees with the proper direction.

6.3.8 PRSUM

PRSUM is called from INPUT to print a summary of the input data values to be used in the GENBOX run. It calls HEADER to control pagination of the output listing and DMS to convert latitude/longitude values into Hollerith print-ready formats in degrees/minutes/seconds and decimal degrees. The GENBOX input data summary will not be printed if errors were found in the input data. It is intended to give the user a summary of the data values used in the GENBOX run that generated a particular BOXTOP auxiliary disk file. The information includes the date and time of the run, the name assigned to the auxiliary file area, and the latitude/longitude boundaries of the area covered by the auxiliary file BOXTOP. All of these input data values are printed from the information stored in common block /GLOBAL/ during INPUT.

6.3.9 FILBOX

FILBOX is the main program of the (2,0) overlay. It controls the extraction of block data records from the TOPOG tapes and stores them on the BOXTOP auxiliary disk file. It also creates block and district directory records for use in randomly accessing the BOXTOP word-addressable file with Record Manager routines. FILBOX initially writes a preface record to the BOXTOP file which contains the 20 character name of the area, the actual latitude/longitude boundaries of the disk area, the date the file was created, and an identification code for the organization that created the file. FILBOX next writes the longitude dimension record to BOXTOP. This record contains the district longitude dimension for each row of districts in the disk area. FILBOX then creates the FIT for the TOPOG directory TOPDRY, requests the tape, and opens the file. FILBOX then reads the TOPOG region directory from file TOPDRY and determines which tape areas intersect the BOXTOP disk area. It requests the proper TOPOG tape for the next tape area to be extracted and temporarily stores its directory records on the scratch file DIRBLK. FILBOX then processes each district in the TOPOG tape area, determining if it intersects the BOXTOP disk area, and saving all the block data records on file BOXTOP for the districts within the desired area. FILBOX builds a two-level directory for the disk file which consists of a master directory giving the starting address and length of each of the district directories. These district directories contain the starting address and length of each block data record in the district. These directory records are also stored on file BOXTOP. When all of the necessary tape areas have been processed, FILBOX summarizes the contents of the BOXTOP file area by printing a status map showing which blocks have data, are missing, or are ocean, for each district in the BOXTOP disk area.

6.3.10 LOADRY

LOADRY is called from FILBOX to request the TOPOG directory file TOPDRY. It stores the volume serial number for the tape (TG0000) and the processing options (9-track, 1600 bpi, I format, PO=RA, and unlabelled) in words 8 and 9 of the FIT for the TOPDRY file. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

6.3.11 LDTOPOG

LDTOPOG is called from FILBOX to request the desired TOPOG tape. It initializes the File Information Table for file TOPOG and then stores the volume serial number of the TOPOG tape to be requested and the processing options (9-track, 1600 bpi, I format, PO=RA, and unlabeled) in words 8 and 9 of the FIT. It then calls the COMPASS routine LBLRQST to issue the actual tape request.

6.3.12 LBLRQST

LBLRQST is a COMPASS routine called from LOADRY to request the directory tape and from LDTOPOG to request the desired TOPOG tape. It has one parameter, IFET, which is an array containing the FET for the file TOPOG. Notice that the FIT and FET addresses are the same since the FET is actually the initial part of the FIT. The proper options and tape the LABEL (NOS) or REQUEST (NOS/BE) macro is used to make the tape request.

6.3.13 RSKIP

RSKIP is a COMPASS routine called from FILBOX to position the TOPOG tape to the desired record. It uses the Record Manager skip macro SKIPFL which requires IOTEXT to be specified when the routine is assembled or compiled. RSKIP has two parameters. The first is the address of the FET for the TOPOG file and the second is the number of logical records to be skipped.

7. SOFTWARE FOR UTILIZING TOPOG DATA

7.1 Path Profile Extraction Routines

The routines PTOPOG and ZTOPOG have been included to extract path profiles from the BOXTOP auxiliary disk files. PTOPOG is a call-compatible revision of G.A. Hufford's (private communication) PFLTPO routine. PTOPOG and ZTOPOG are designed to replace his PFLTPO, ELVTPO, LDDTPO, READPRF, and ISEARCH routines where the TOPOG data base is to be used instead of the 30-second TOPO data base.

PTOPOG is called with six parameters. The first two are the latitude and longitude of one endpoint of the path and the next two are the latitude and longitude of the other endpoint of the path given in decimal degrees north and east. The fifth parameter is an initial estimate of the distance increment between points of the profile. The actual distance increment may vary slightly since the profile points will be equally spaced along the profile. The last parameter is an error flag which is returned from ZTOPOG. PTOPOG initially calculates the path length number of profile points and the actual distance increment between points. It then calls ZTOPOG to retrieve the terrain elevation value for each point along the profile.

6.3.12 LBLRQST

LBLRQST is a COMPASS routine called from LOADRY to request the directory tape and from LDTOPOG to request the desired TOPOG tape. It has one parameter, IFET, which is an array containing the FET for the file TOPOG. Notice that the FIT and FET addresses are the same since the FET is actually the initial part of the FIT. The proper options and tape the LABEL (NOS) or REQUEST (NOS/BE) macro is used to make the tape request.

6.3.13 RSKIP

RSKIP is a COMPASS routine called from FILBOX to position the TOPOG tape to the desired record. It uses the Record Manager skip macro SKIPFL which requires IOTEXT to be specified when the routine is assembled or compiled. RSKIP has two parameters. The first is the address of the FET for the TOPOG file and the second is the number of logical records to be skipped.

7. SOFTWARE FOR UTILIZING TOPOG DATA

7.1 Path Profile Extraction Routines

The routines PTOPOG and ZTOPOG have been included to extract path profiles from the BOXTOP auxiliary disk files. PTOPOG is a call-compatible revision of G.A. Hufford's (private communication) PFLTPO routine. PTOPOG and ZTOPOG are designed to replace his PFLTPO, ELVTPO, LDDTPO, READPRF, and ISEARCH routines where the TOPOG data base is to be used instead of the 30-second TOPO data base.

PTOPOG is called with six parameters. The first two are the latitude and longitude of one endpoint of the path and the next two are the latitude and longitude of the other endpoint of the path given in decimal degrees north and east. The fifth parameter is an initial estimate of the distance increment between points of the profile. The actual distance increment may vary slightly since the profile points will be equally spaced along the profile. The last parameter is an error flag which is returned from ZTOPOG. PTOPOG initially calculates the path length number of profile points and the actual distance increment between points. It then calls ZTOPOG to retrieve the terrain elevation value for each point along the profile.

ZTOPOG is a function called with three parameters. The first two are the latitude and longitude of the point for which the terrain elevation value is requested in decimal degrees north and east and the third is an error flag. The error codes are 0=ok, 8=the missing data were filled in using an averaging technique, -1=point not in BOXTOP file area, -2=block data record missing, and -3=too many missing data points. A negative error code indicates a fatal error, and ZTOPOG returns an elevation value of -10,000 meters to the calling program. The terrain elevation value is returned as the value of the function in meters. ZTOPOG initializes the File Information Table for the BOXTOP file and opens the file the first time it is called. It also reads the file preface and district directory records from the file. On subsequent calls ZTOPOG checks to see whether the point requested is in the current TOPOG block data record. If not, it checks to see whether the point is within the current district. If so, ZTOPOG reads the proper block data record for the TOPOG block containing that point. Otherwise, it must first retrieve the block directory record for the district containing the point, and use it to read the proper block data record. Once the correct block data record has been retrieved, ZTOPOG extracts the terrain elevation values of the four corners TOPOG cell surrounding the desired point. If all four corner values are present, standard four-point bivariate interpolation is used to determine the elevation at the point. If all four corner values are missing, an error is returned. If one to three corners are missing, they are replaced with the average of the other values and the interpolation process is used to approximate the terrain elevation value for the point.

7.2 Path Profile Comparisons

In this section, we illustrate terrain elevation profiles along three selected paths in western Washington and adjacent portions of Oregon. The exact definitions of these paths are as follows.

(1) Orcas Island Path: (48°42'00"N,122°20'00"W) to (45°15'00"N,123°06'00"W); path length is 81.01 km.

(2) Mount Hood Path: (45°45'00"N,122°20'00"W) to (45°15'00"N,121°30'00"W); path length is 85.37 km.

(3) Seattle-Portland Double Horizon Path: (47°37'57"N,122°20'59"W) to (45°32'29"N,122°30'29"W); path length is 233.08 km.

Figure 7-1 shows the Orcas Island path profile obtained from data manually read from relevant 15- and 7 1/2-minute quadrangles. The profile in Figure 7-2 was derived from a BOXTOP auxiliary terrain elevation file covering western Washington and adjacent portions of Oregon. This file was generated by program GENBOX from the Victoria (TG2628) and Seattle (TG2630) TOPOG terrain elevation files. The actual profile extraction was performed by the subroutines PTOPOG and ZTOPOG during a run of a TOPOG version of CSPM, a computer program for analyzing communication system performance models (Jennings and Paulson, 1977). A third Orcas Island path profile is shown in Figure 7-3. This profile was extracted from the 30-second TOPO data base during a run of the TOPO version of program CSPM. Figures 7-4 and 7-5 show, respectively, a comparison of the hand-scaled profile with that extracted from the 3-second TOPOG data base and the 30-second TOPO data base. Figures 7-6 through 7-10 and 7-11 through 7-15 show, respectively, the analogous profiles along paths across Mount Hood and from Seattle to Portland.

When comparing profiles for a given path, one should be aware that the 3-second TOPOG data and 30-second TOPO data have been derived from a common source consisting of a digital approximation of the contours on 1:250,000-scale topographic maps. In obtaining that digital representation, each contour line was manually traced with the stylus of a machine called a digitizing graphical recorder. Interpolation algorithms were then applied to these digital data to obtain elevation values at the points of the DMA data grid.

The TOPOG (and TOPO) data thus reflect errors in the original maps (these maps do not necessarily comply with National Map Accuracy Standards), plus those introduced in the digitizing and interpolation procedures. Given this potential for error, it is perhaps surprising that the differences between hand-scaled profiles and those derived from DMA data are not greater.

Interpolation errors are especially serious in areas of rather flat relief, where the 100- or 200-foot contour interval characteristic of 1:250,000-scale maps does not adequately define the terrain surface. An example of this can be seen in Figure 7-9, near kilometer 26 of the Mount Hood

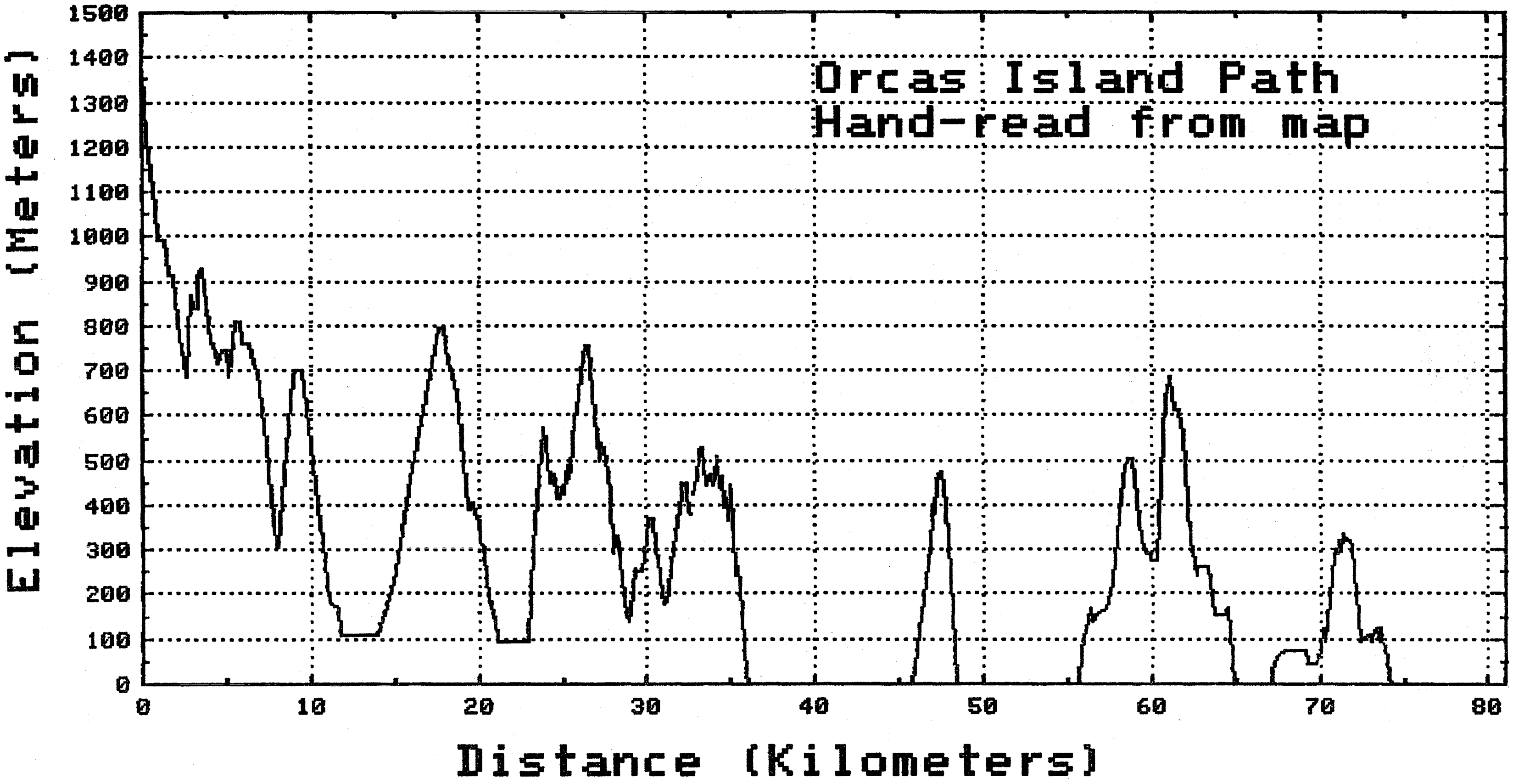


Figure 7-1. Orcas Island path profile hand-scaled from standard USGS quadrangles.

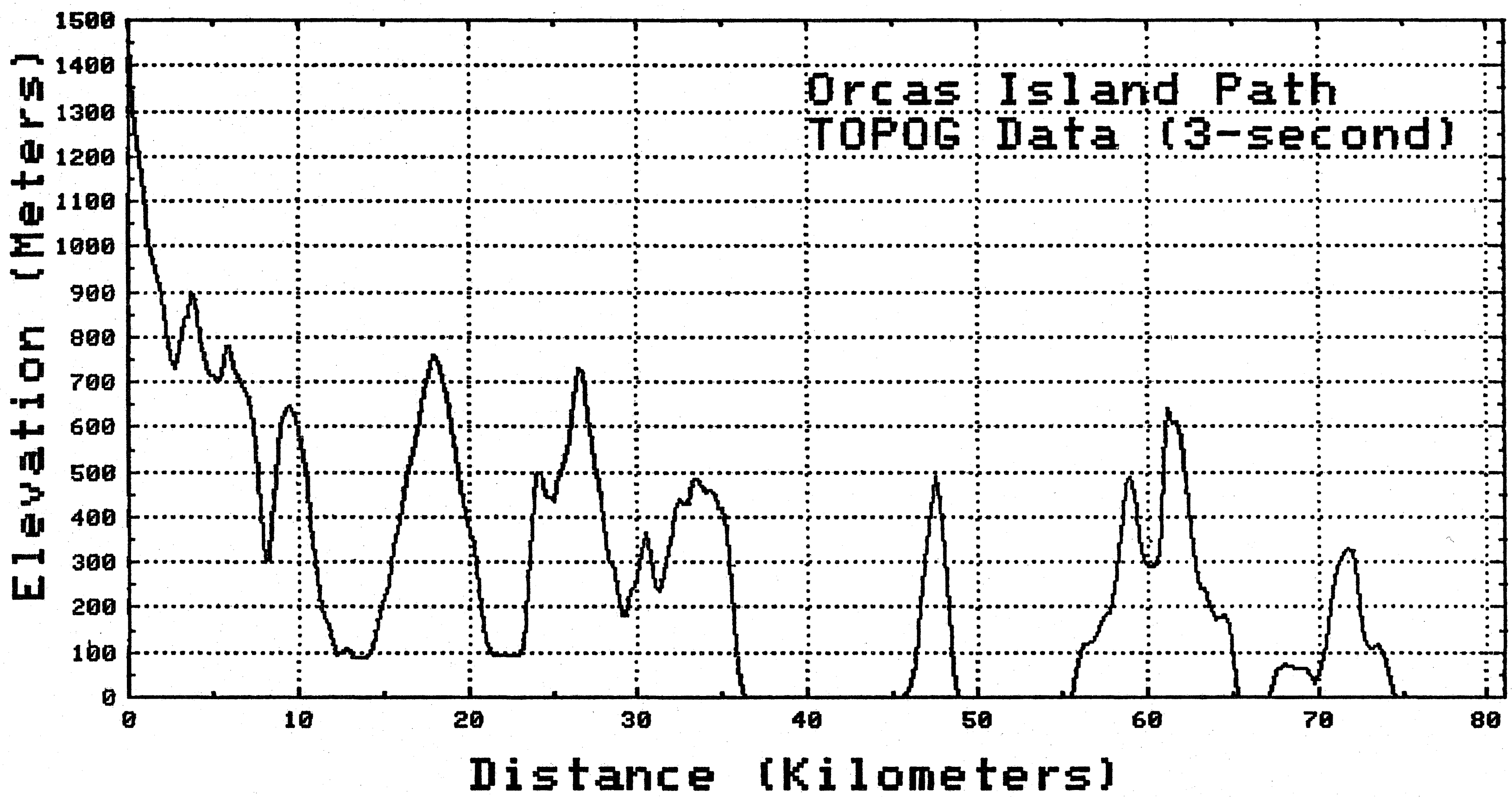


Figure 7-2. Orcas Island path profile extracted from 3-second TOPOG data.

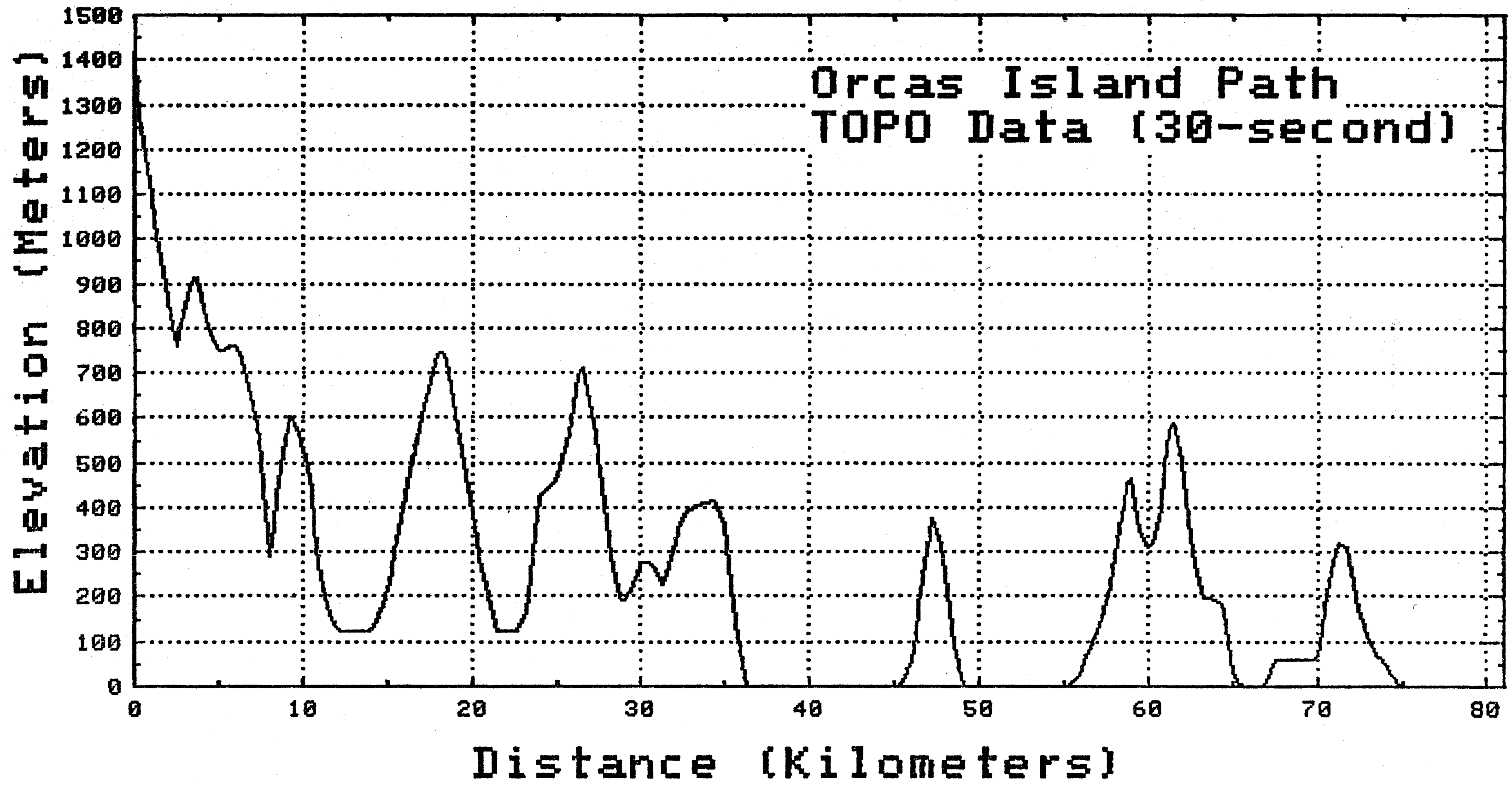


Figure 7-3. Orcas Island path profile extracted from 30-second TOPO data.

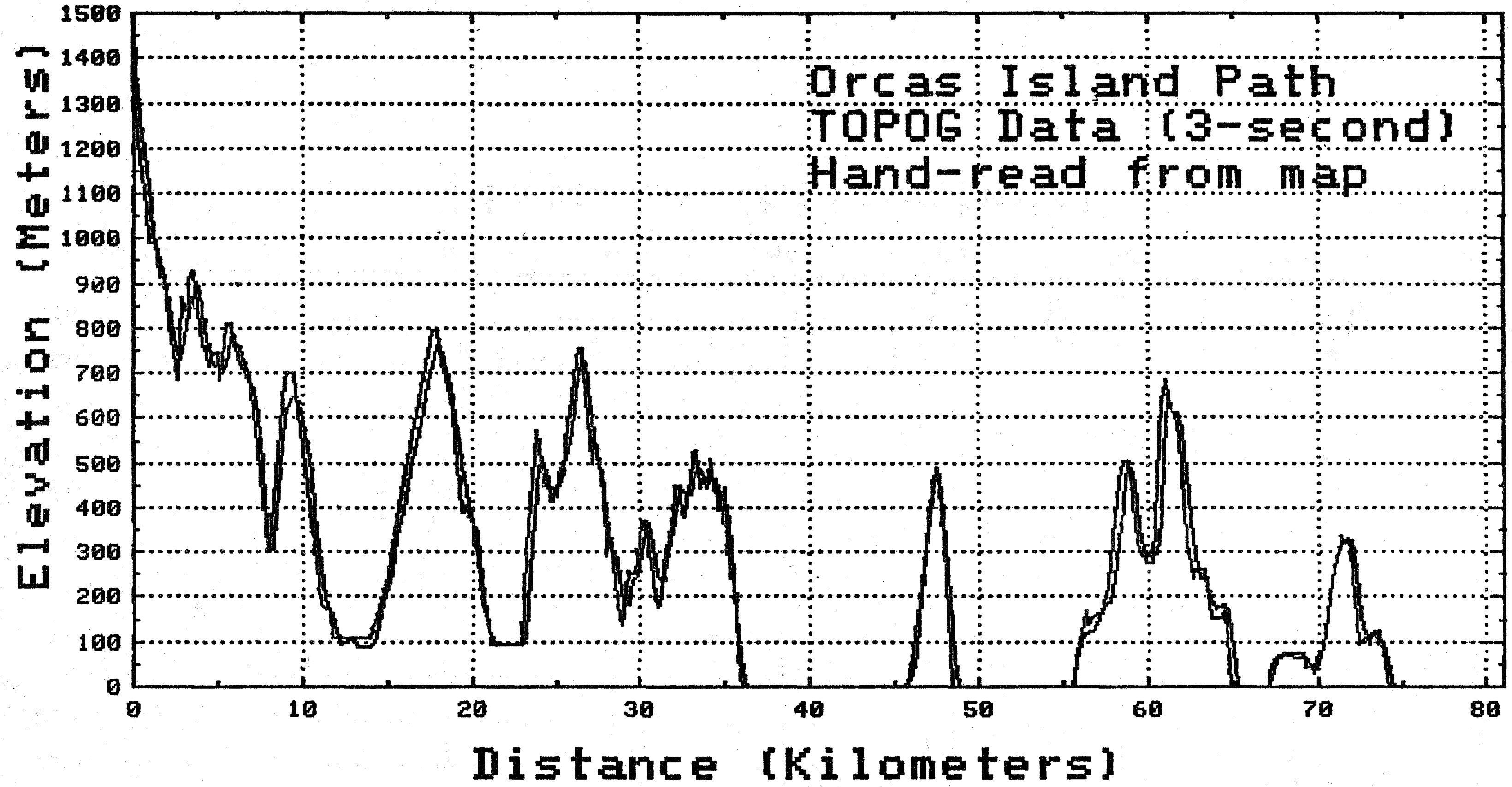


Figure 7-4. Comparison of hand-scaled and TOPOG 3-second profiles for Orcas Island path.

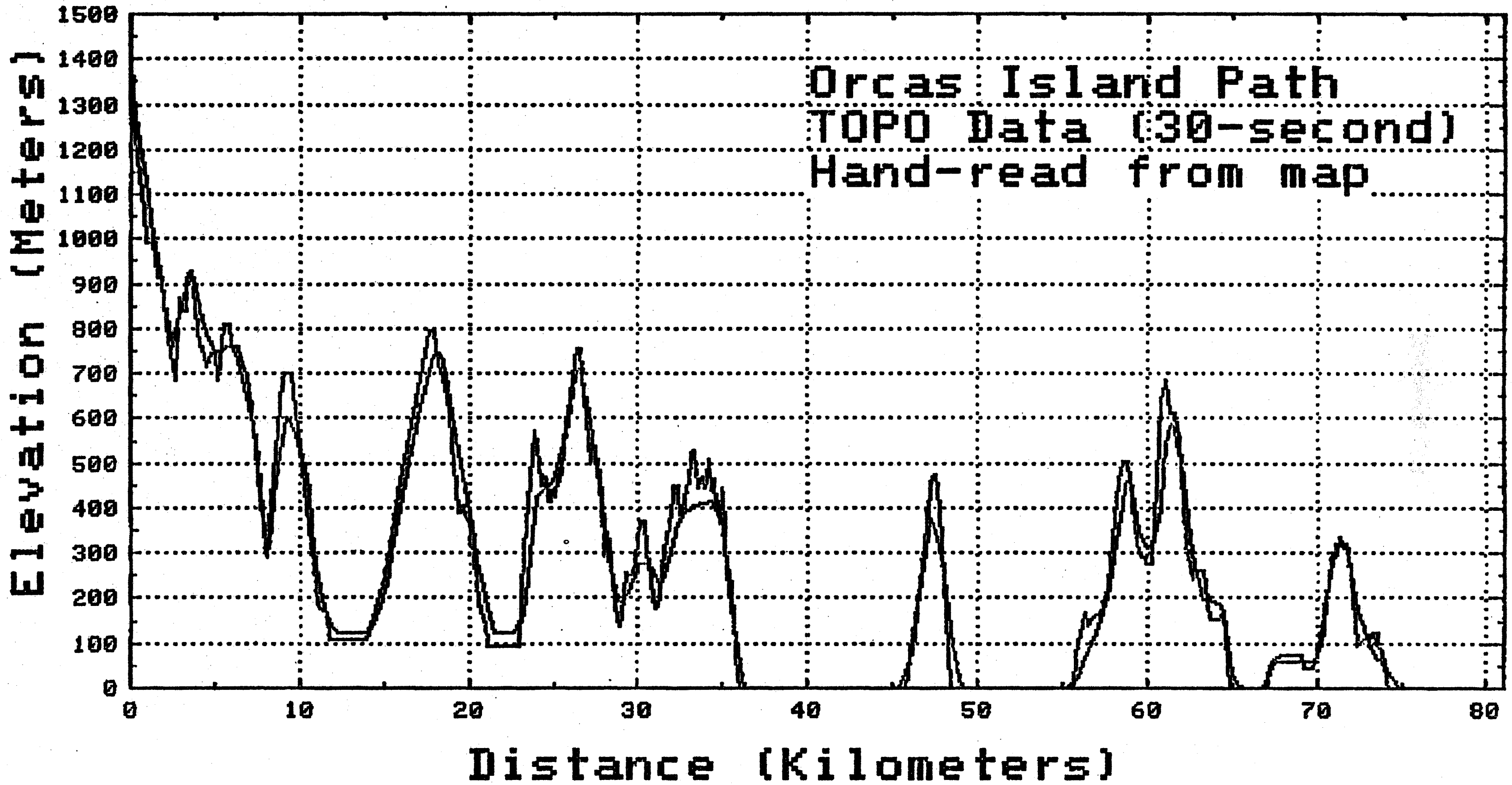


Figure 7-5. Comparison of hand-scaled and TOPO (30-second) profiles for Orcas Island path.

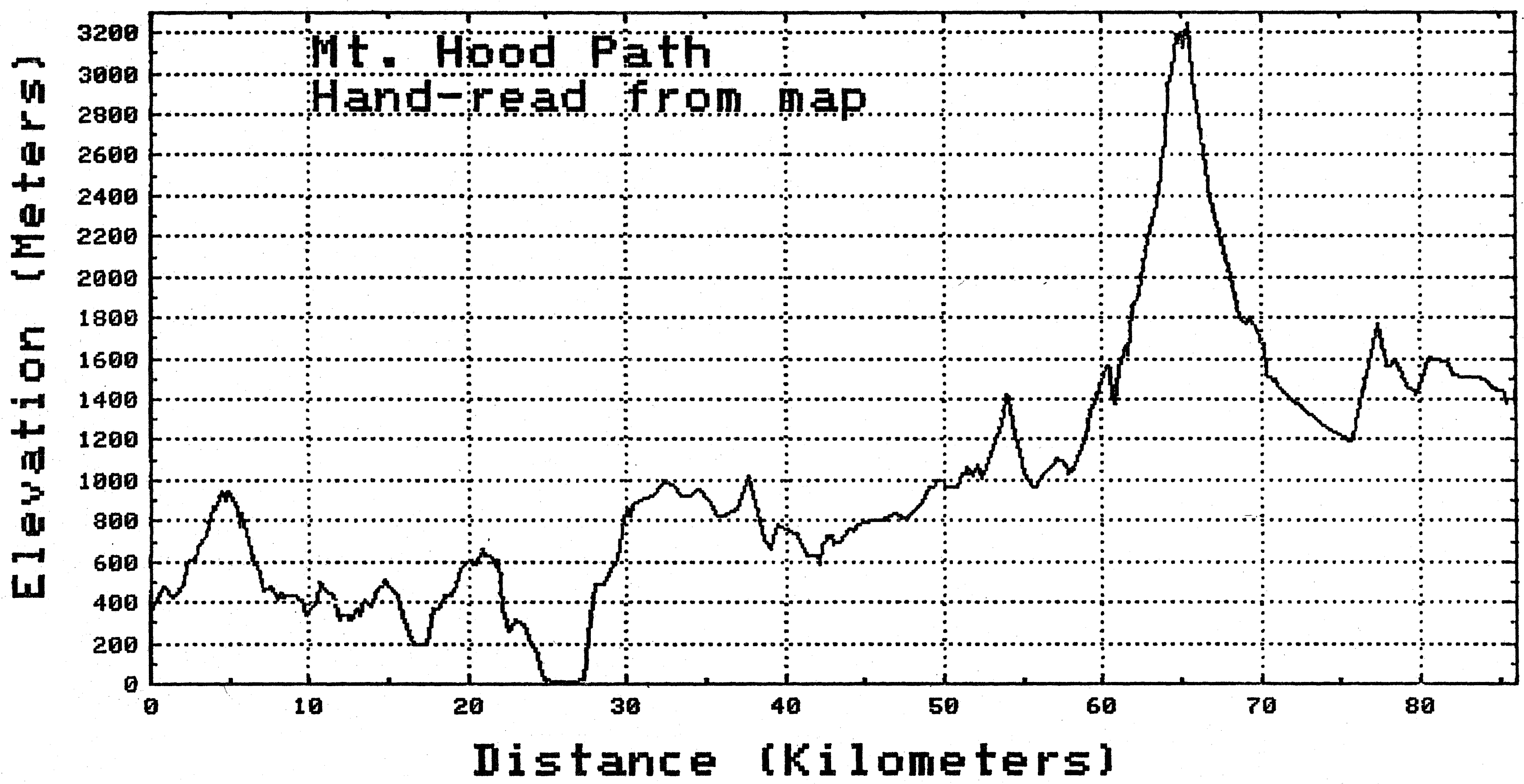


Figure 7-6. Mount Hood path profile hand-scaled from standard USGS quadrangles.

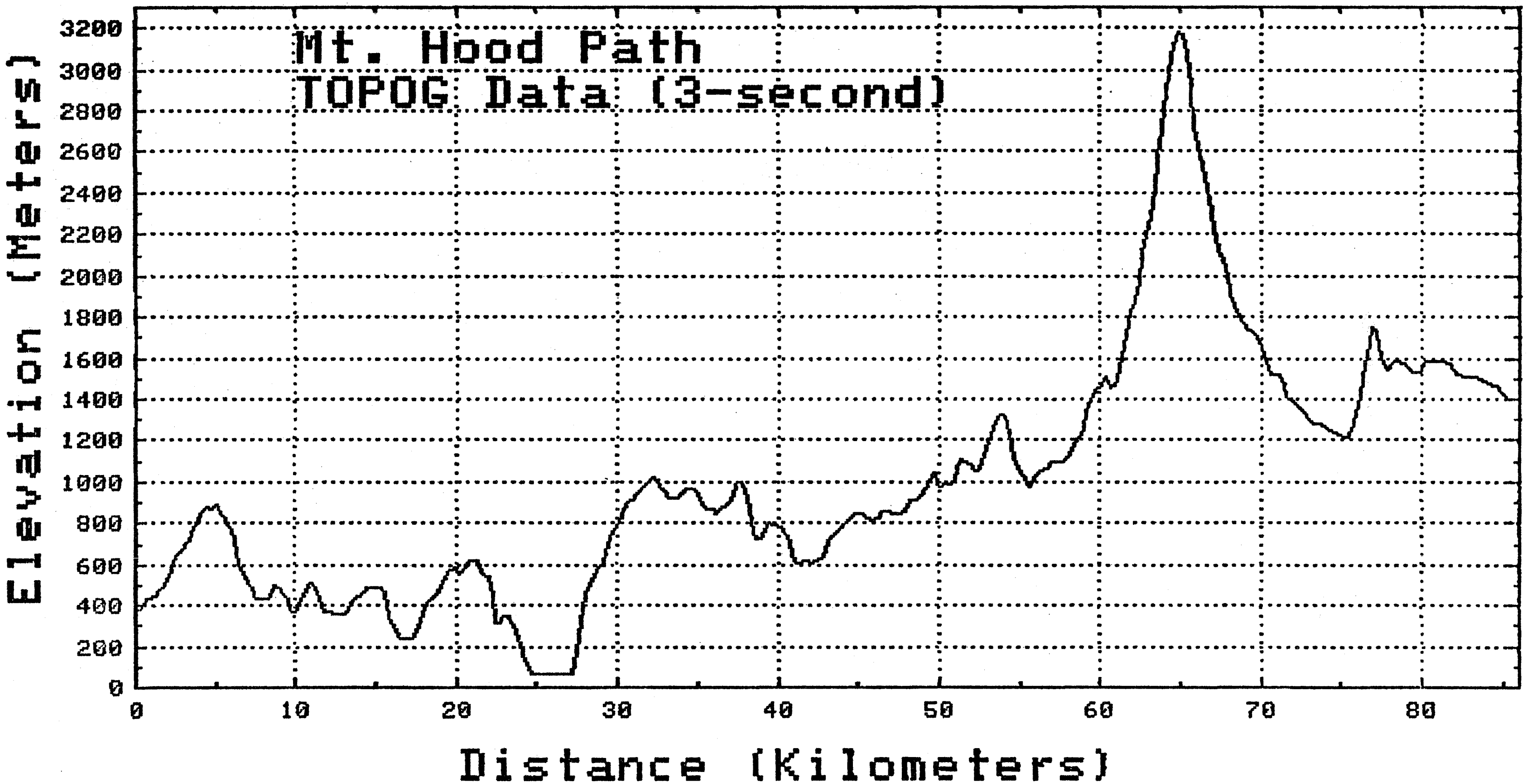


Figure 7-7. Mount Hood path profile extracted from 3-second TOPOG data.

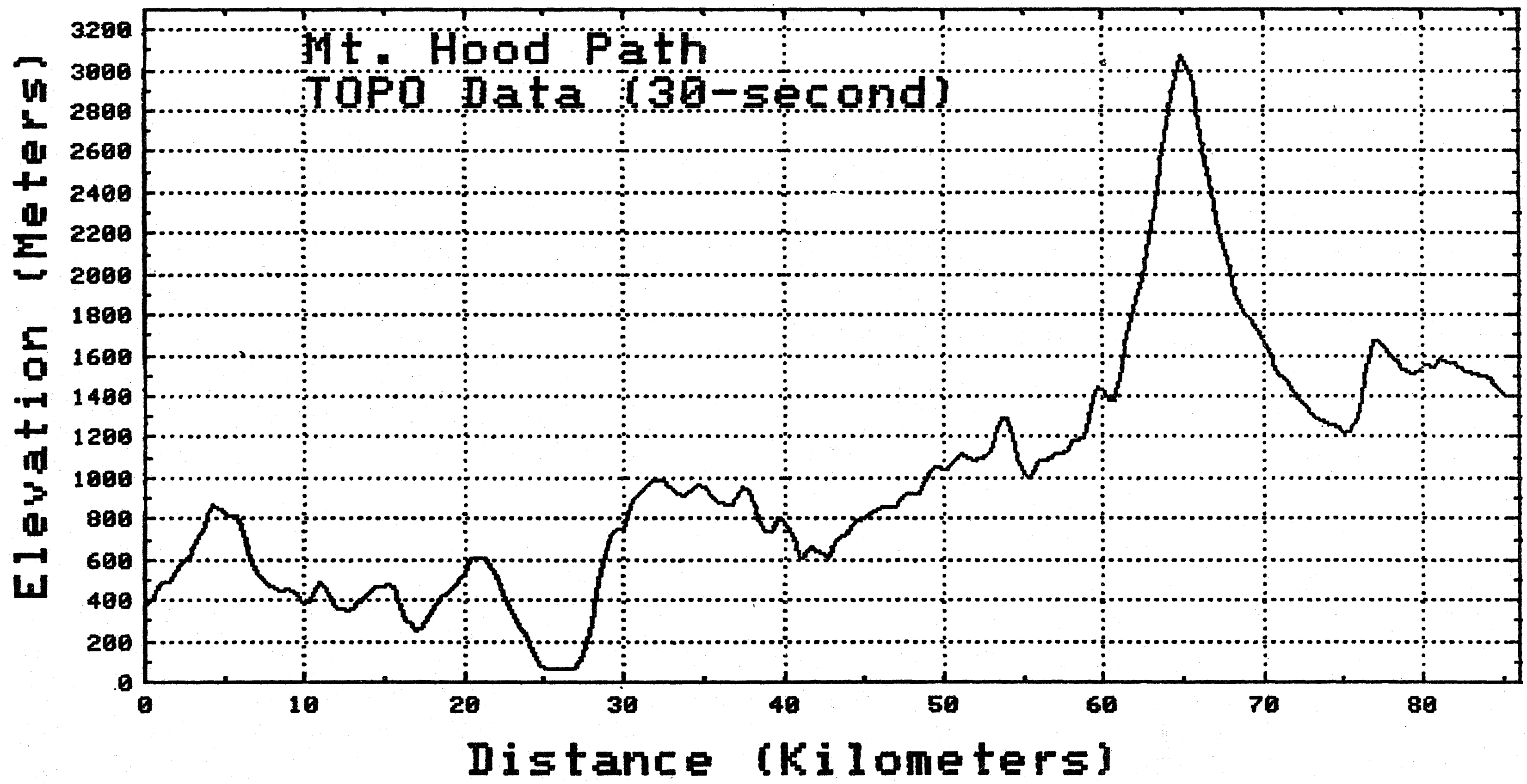


Figure 7-8. Mount Hood path profile extracted from 30-second TOPO data.

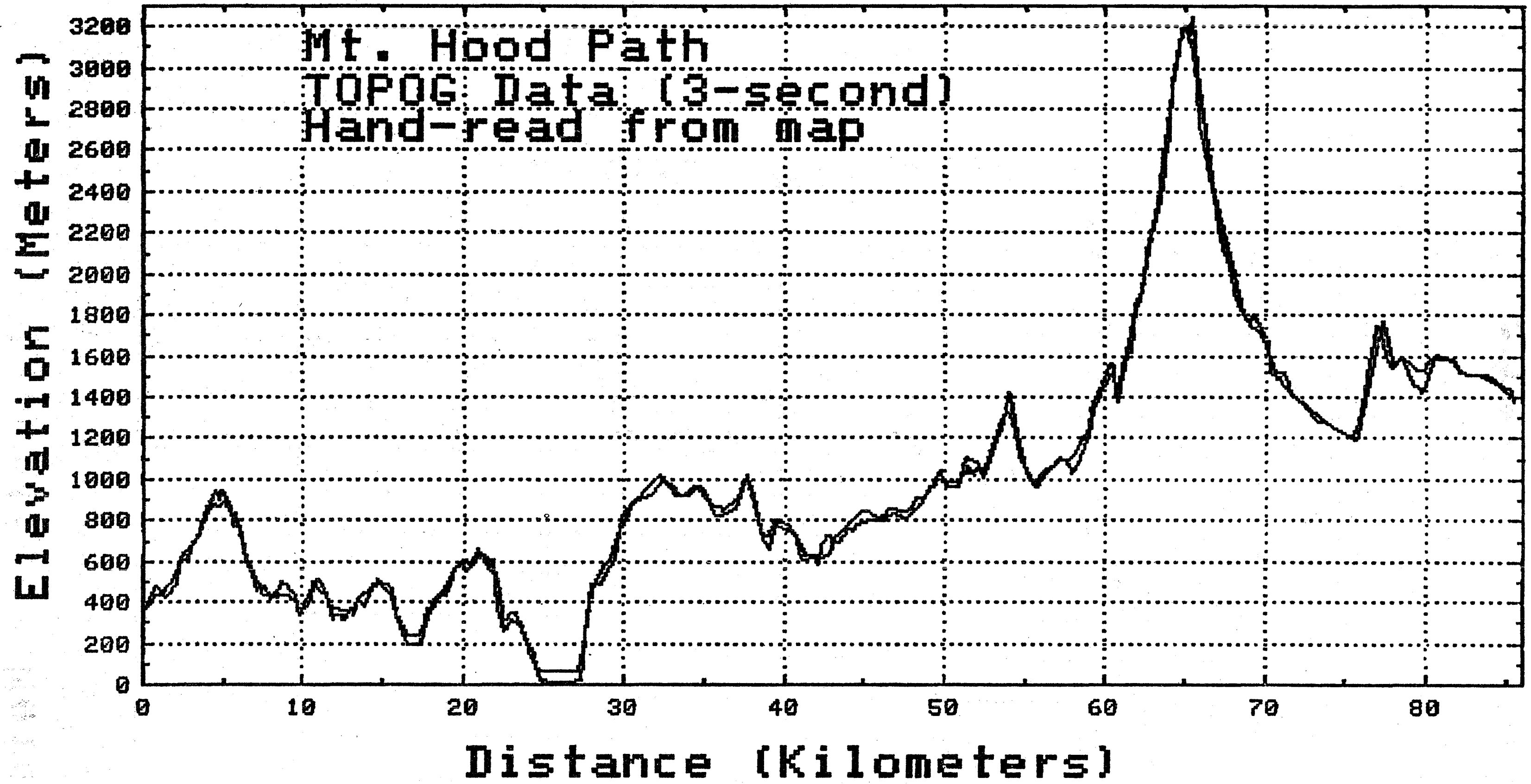


Figure 7-9. Comparison of hand-scaled and TOPOG (3-second) profiles for Mount Hood path.

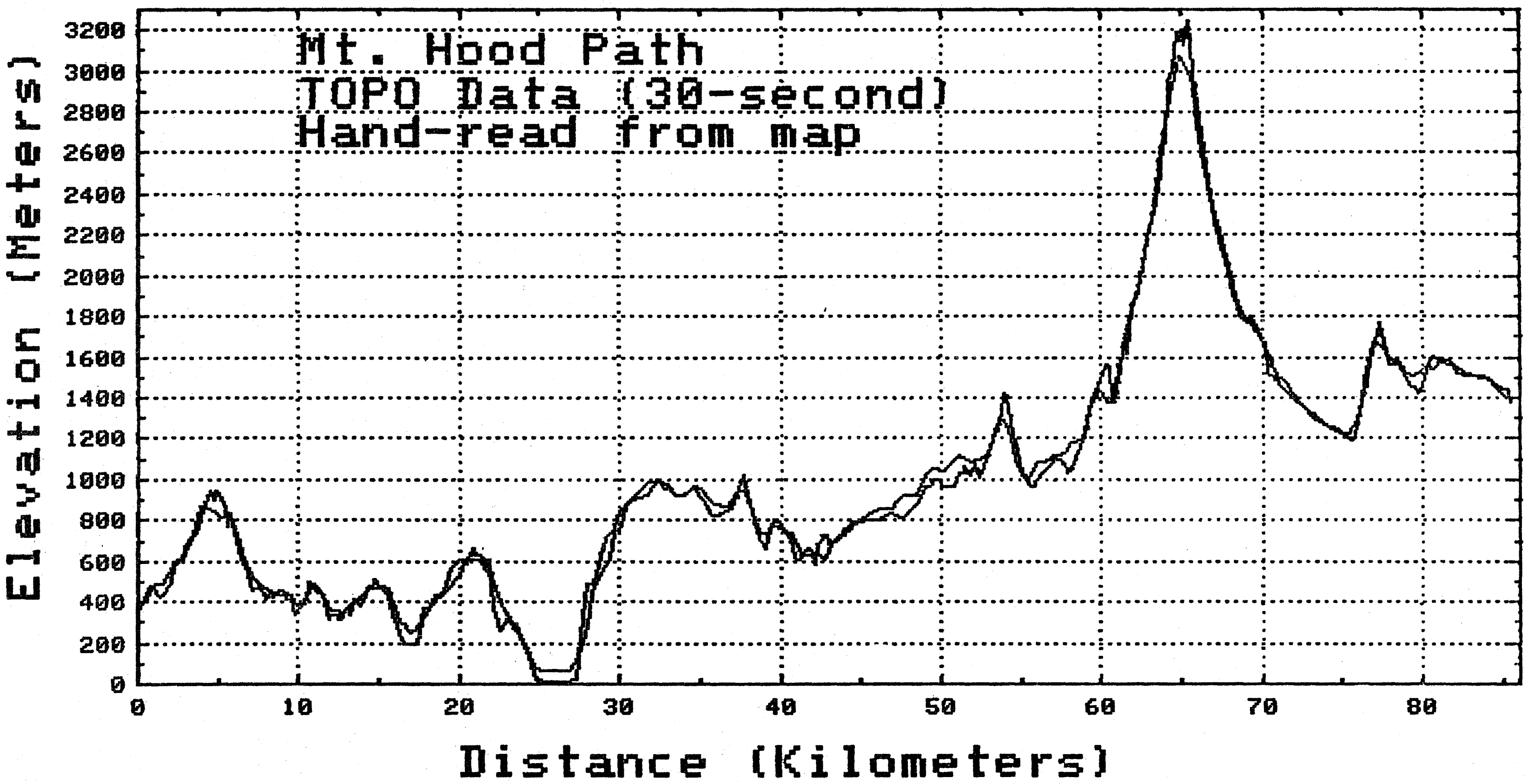


Figure 7-10. Comparison of hand-scaled and TOPO (30-second) profiles for Mount Hood Path.

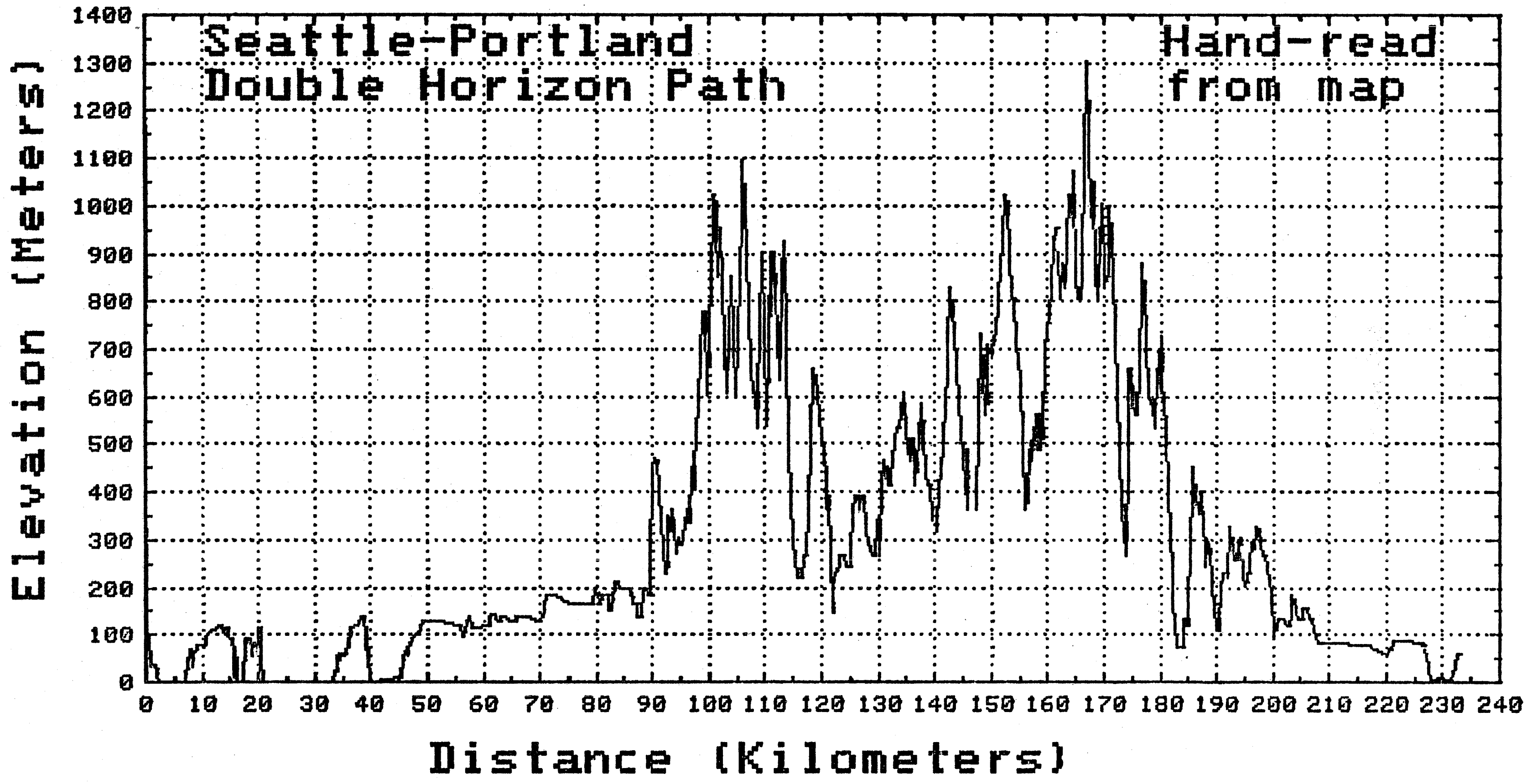


Figure 7-11. Seattle-Portland path profile hand-scaled from standard USGS quadrangles.

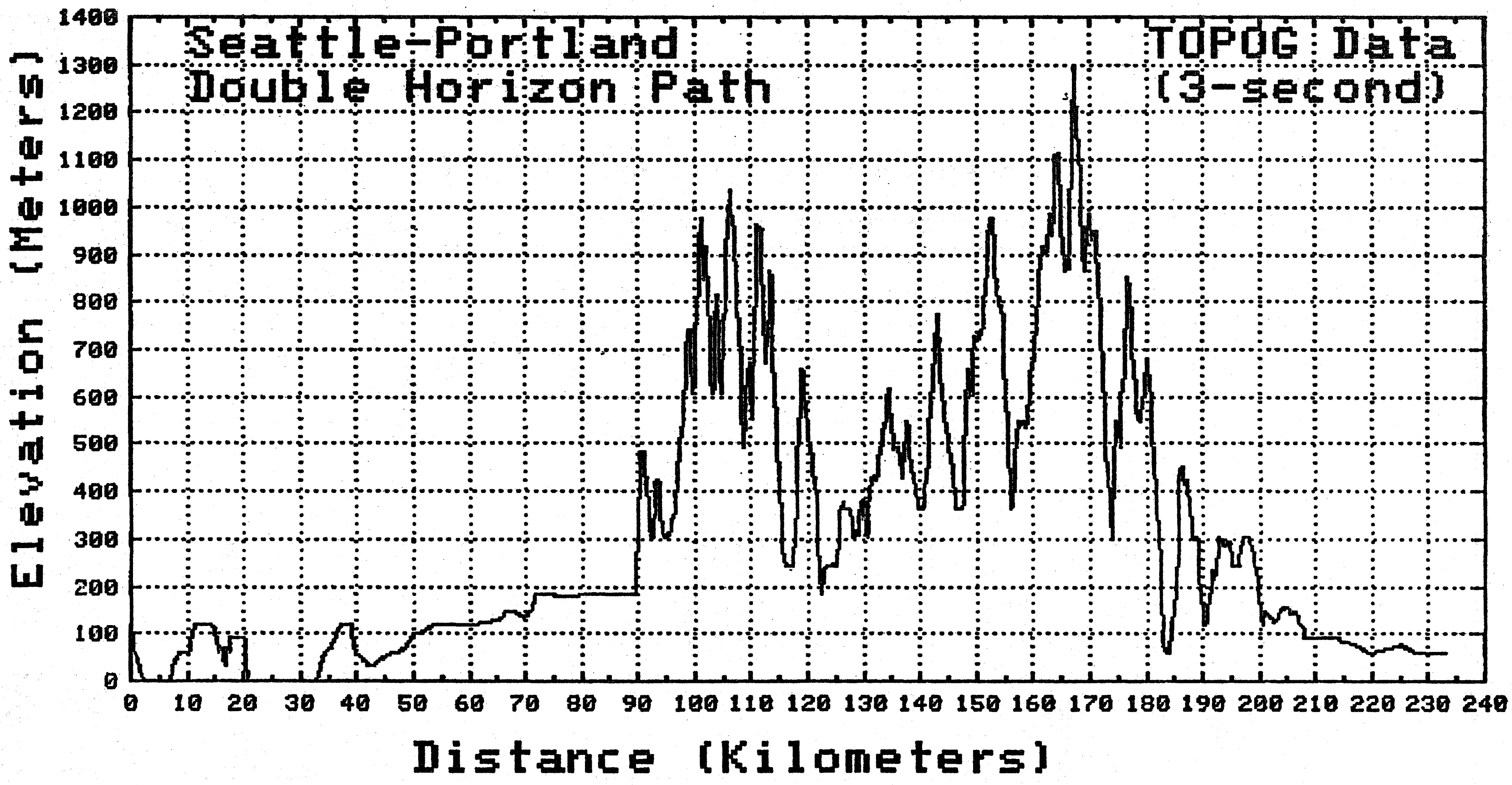


Figure 7-12. Seattle-Portland path profile extracted from 3-second TOPOG data.

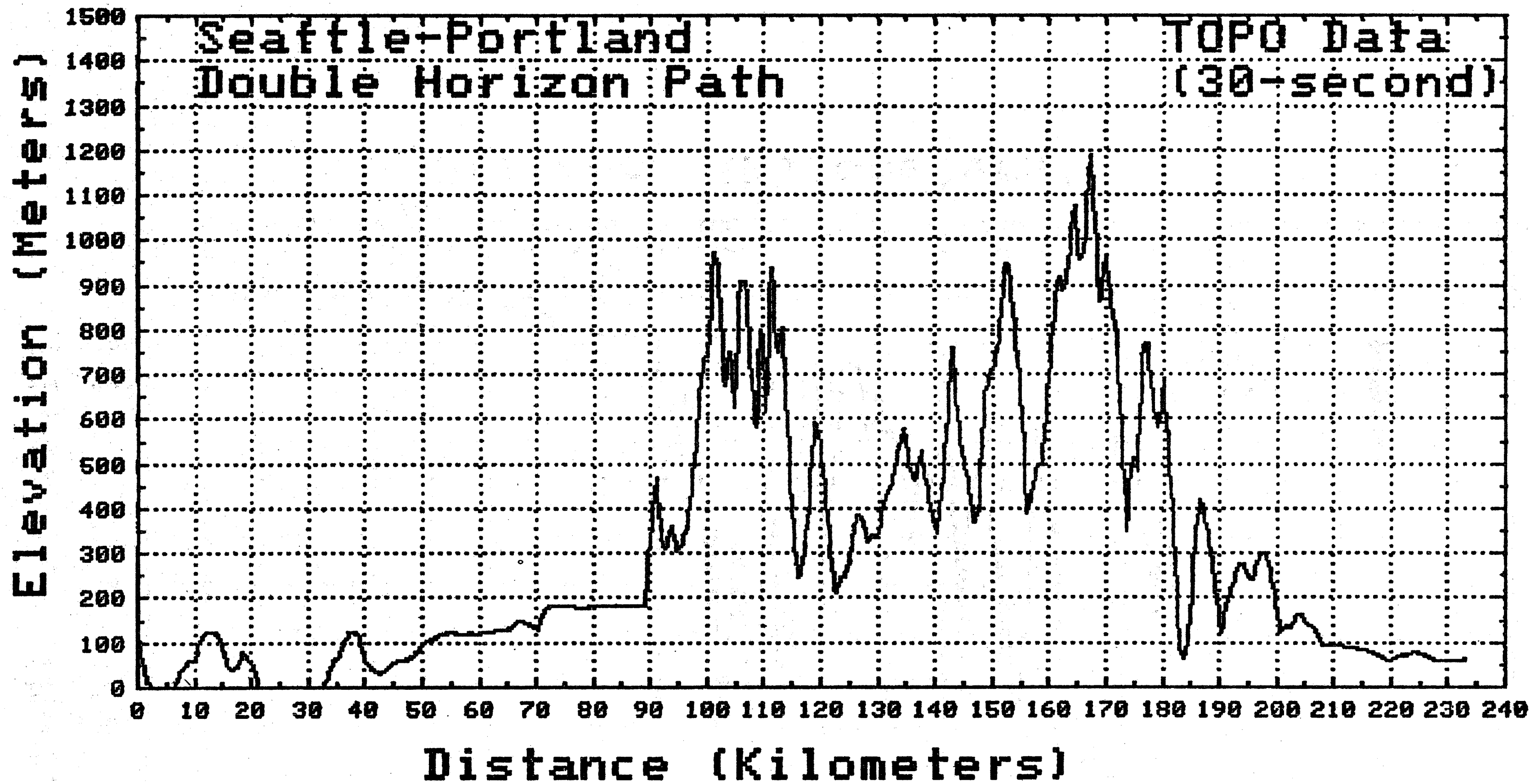


Figure 7-13. Seattle-Portland path profile extracted from 30-second TOPO data.

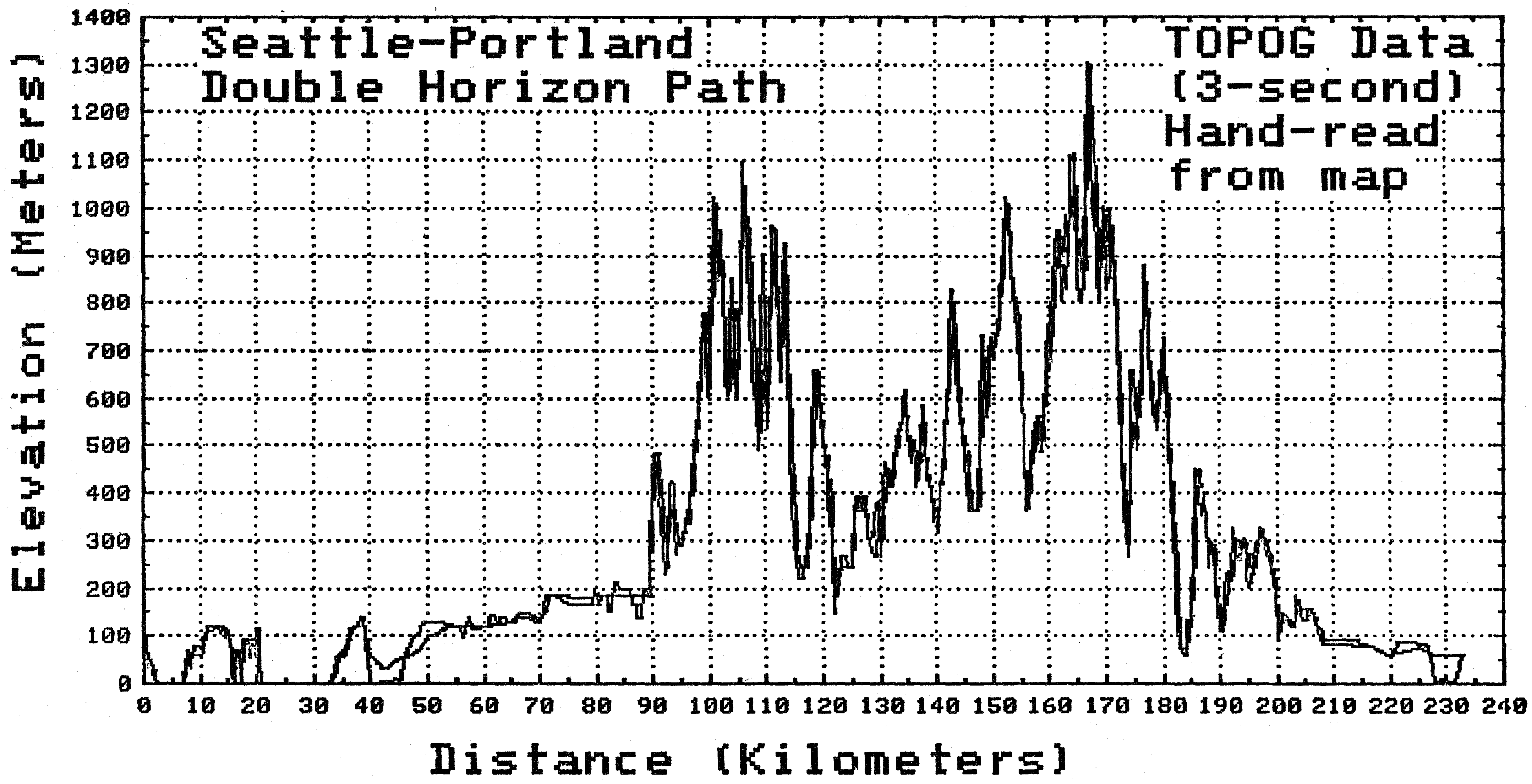


Figure 7-14. Comparison of hand-scaled and TOPOG (3-second) profiles for Seattle-Portland path.

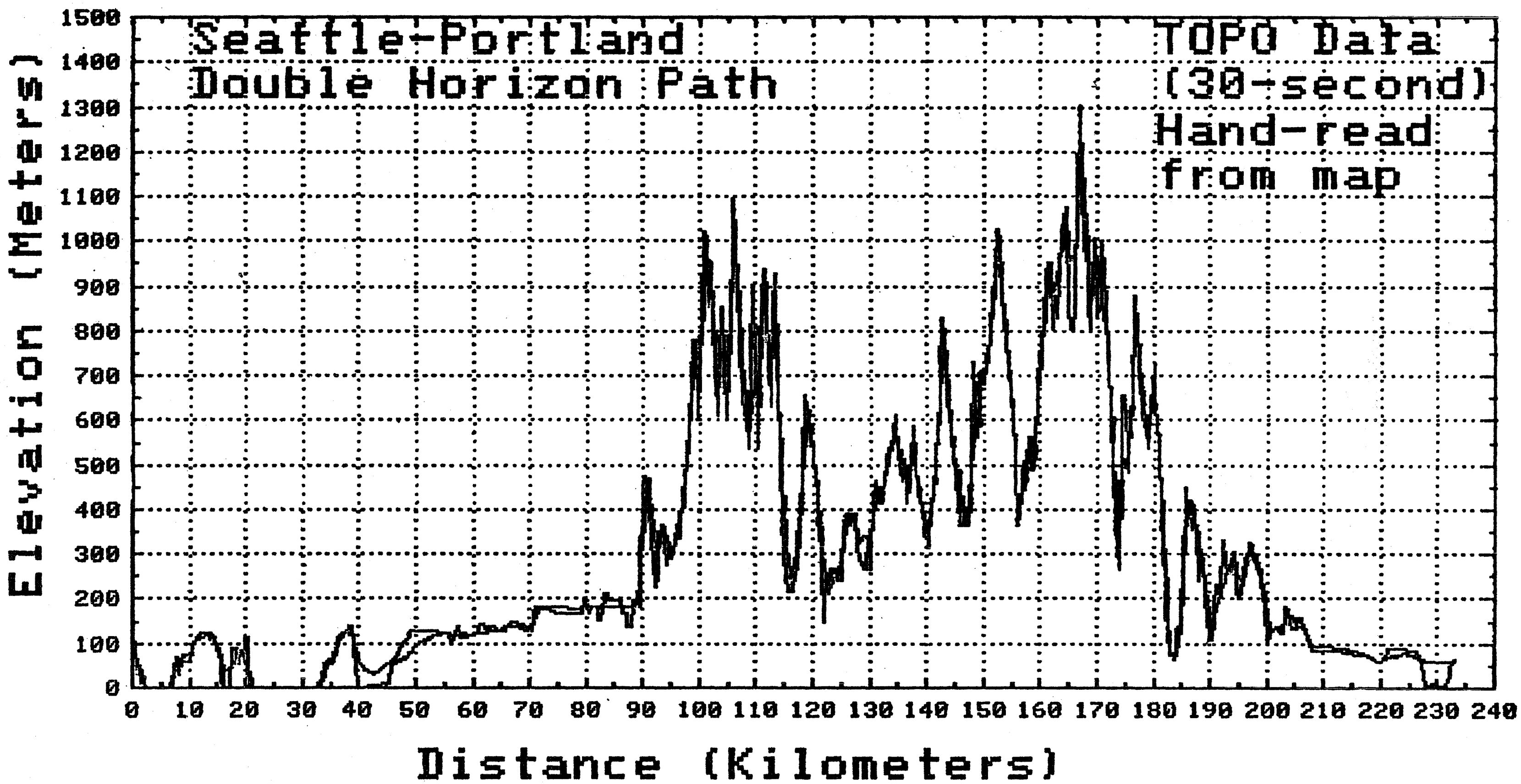


Figure 7-15. Comparison of hand-scaled and TOPO (30-second) profiles for Seattle-Portland path.

path. There the path crosses the Columbia River which is only about 50 feet above sea level at that point. The DMA elevations at the river result from interpolating between the 200-ft contour lines which lie along opposite sides of the valley to obtain a value of 197 ft (61 m). The same phenomenon is illustrated in Figure 7-14, near kilometer 230 of the Seattle-Portland path. There the geographical feature is again the Columbia River.

The expected smoothing effect is discernible in all profiles extracted from the 30-second TOPO data, and is especially evident in the Seattle-Portland path over ridge-tops. Vertical discrepancies on the order of 100 meters below true elevations are fairly common.

8. ACKNOWLEDGMENTS

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APPENDIX

FORMAT OF DMA LEVEL 1 STANDARD FILES

Magnetic tapes containing DMA Level 1 Standard Files used in developing the software described in this report were obtained from the Defense Mapping Agency Aerospace Center in St. Louis, Missouri. This Appendix presents detailed descriptions of the format and contents of these tapes.

Each file corresponds to a 1° x 1° area called a block. Block boundaries are integer multiples of 1°. On a given tape, the files correspond to a west-to-east sequence of blocks. The latitude interval between adjacent data points is three seconds; the longitude intervals depend on latitude and are given in Table 1-1.

A data record contains the elevations for a south-to-north sequence of data points along a meridian spanning the block. All elevations are expressed in meters above mean sea level, and are stored as signed 16-bit binary integers with the sign in the high order position. A "missing" elevation value is represented by all ones.

1. PHYSICAL CHARACTERISTICS.

a. Magnetic Tape - 2400 feet length, 1/2 inch width, 9 tracks, 1600 bpi recording density, phase encoded (p.e.) recording method, ASCII header record, binary data records, odd parity.

b. Recorded Label - American National Standard Magnetic Tape Labels for Information Interchange X327-1969 (refer to Section 3.2.2 for comments regarding these labels).

c. Control Characters - Software end-of-file (EOF) between data files, 2 hardware EOF at end of information on reel, physical end-of-tape (EOT) marks at beginning and end of tape.

d. Record Size - Variable length.

e. Block Size - Same as indicated in above Record Size section.

f. Blocking Factor - 1:1 (Block Size = Record Size).

g. Recording Equipment and System - UNIVAC UNISERVO 16C, Exec 8 operating system.

h. Inter-record Gap - UNISERVO 16C (1600 bpi) - .6".

i. Multiple File - Each file is identified by header records and trailer records, as follows:

```
VOL    1    (Volume Header Label)
HDR    1    (File Header Label)
UHL    1    (User Header Label)
       *
  Data Record   \
       .         |
       .         >        (First File)
       .         |
  Data Record   /
       *
EOF    1    (End of File)
UTL    1    (User Trailer Label)
       *
HDR    1
UHL    1
       *
  Data Record   \
       .         |
       .         >        (Second File)
       .         |
  Data Record   /
EOF    1
UTL    1
       *
       *
```

* = tape marks

2. TAPE LABELS. Tape Labels are each 80 characters long and are described as follows:

VOLUME HEADER LABEL

Field Contents	Field Length In Characters	Description
VOL	3	Recognition sentinel
1	1	Fixed by standard
reel number	6	Six alphanumeric characters identifying the physical reel

VOLUME HEADER LABEL (continued)

Field Contents	Field Length in Characters	Description
Blank or nonblank	1	Nonblank indicates restricted access, as the tape reel is privately owned.
blanks	26	Unrequired available space
account number	14	Account number of owner if this is a privately owned tape reel (UNIVAC uses a maximum of 12 characters left-justified, space filled).
blanks	28	Fixed by standard
1	1	Fixed by standard

FILE HEADER LABEL

Field Contents	Field Length In Characters	Description
HDR	3	Recognition sentinel.
1	1	Fixed by standard.
File name	17	Left-justified file name. The first 12 characters are referenced by the Executive System for comparison with the file name portion of the external file name.
UNIVAC	6	Fixed as a set identifier when referenced by system.
0001	4	Reel sequence number within a file.
0001 reel	4	File sequence number within a reel which is fixed at 1.
0001 00	4 2	Generation and version numbers which are fixed at 1 and 0.
creation date	6	A blank followed by two characters for the year followed by three characters for the date (001 through 356) within the year

FILE HEADER LABEL (continued)

Field Contents	Field Length in Characters	Description
expiration date	6	Same format as creation date field. The date after which this tape reel may be considered as available for reallocation.
accessibility	1	A space indicates unlimited access to this reel and 15_8 - This reel is catalogued (on tape) 35_8 - This reel is catalogued with read key 55_8 - This reel is catalogued with write key 78_8 - This reel is catalogued with read and write key
block count	6	Fixed at zeros.
qualifier	13	Used by the Executive Operating System (UNIVAC uses a maximum of 12 characters left justified space filled).
blanks	7	Fixed by standard.

USER HEADER LABEL (ASCII)

Field Contents	Field Length in Characters	Description
UHL	3	Recognition Sentinel.
1	1	Fixed by standard.
sexagesimal	8	Longitude S.W. Corner. ddd mm ss
sexagesimal	8	Latitude, S.W. Corner ddd mm ss

USER HEADER LABEL (ASCII) (continued)

Field Contents	Field Length in Characters	Description
seconds longitude	4	Longitude data interval (tenth of seconds SSSS).
seconds latitude	4	Latitude data interval (tenth of seconds SSSS).
accuracy code	4	Data accuracy code.
security code	3	Code designating security DoD Reference #SE-FB
Unique Reference Number	12	Unique Reference Number (Provide pointer to file containing detailed file description).
Number of Longitude lines	4	Count of the number of longitude (profiles) lines.
Number of Latitude points	4	Count of the number of latitude points per longitude line.
reserved	25	Unused portion for future use.

USER TRAILER LABEL (ASCII)

Field Contents	Field Length in Characters	Description
UTL	3	Recognition Sentinel
1	1	Fixed by Standard.

(See User Header Label for remainder of UTL fields)

3. DATA RECORDS

Field Contents	Field Length in Characters 8 binary bits per Character	Description
252_8	1	Recognition sentinel
data block count	3	Sequential count of the block within the file (FXBIN).
longitude count	2	Count of the meridian True longitude = Longitude Count x data interval + origin (S.W. corner) (FXBIN).
Elevation 1	2	True elevation value of point 1 of meridian in meters (FXBIN).
Elevation 2	2 . .	True elevation value of point 2 of meridian in meters (FXBIN).
Elevation N	2	True elevation value of point N of meridian in meters (FXBIN).
Check sum	4	Algebraic addition of content of block ignoring overflow.

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

TOPOG is a computerized worldwide terrain elevation data base generation and retrieval system. It consists of software to generate TOPOG tapes from Defense Mapping Agency (DMA) standard terrain elevation data tapes, to create auxiliary random-access disk files containing TOPOG data for a user-defined area, and to extract path profiles from the auxiliary disk files. The data base and software are designed for a CDC 6000 series computer with a NOS or NOS/BE operating system.

16. Key Words *(Alphabetical order, separated by semicolons)*
computer software; data base; terrain elevation data; TOPOG

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