LARGE SYSTEM MAPPING AND RELATED DATA BASE EXPERIENCE

David Holland
Supervisory Cartographer
DMA Hydrographic/Topographic Center
6500 Brookes Lane
Washington, D.C. 20315

The Defense Mapping Agency (DMA) has digitized a variety of map and chart related data. Our largest data base contains digitized terrain elevations. What started as an experimental effort in 1964 has grown to a large production data base operation. These holdings were derived from maps and aerial photography. This paper describes the terrain elevation data base contents, how it has been obtained, and production changes that have taken place based on experience.

The definition of a large scale digital data base is quite nebulous therefore a more specific description appears to be in order. The digitized terrain elevation data base discussed in this paper contains over two billion elevations covering over four million square nautical miles (SNM) of the Earth's surface, which are categorized into three levels, and is growing daily. The majority of these elevations are organized in 1^{o} by 1^{o} cells that contain an elevation for each 3 seconds of latitude and longitude. These data are categorized as Level I. The accuracy of these elevations is usually commensurate with 1:250,000 scale mapping specifications. Relative and absolute accuracy statements are included in the header information for each specific cell.

The holdings and requirements for Level II data are now starting to grow and are taxing current production procedures due to the increased volume and more stringent accuracies required. Level II is organized in 15' by 15' cells containing an elevation for each 1 second of latitude and longitude. The accuracy of these data is usually commensurate with 1:50,000 scale mapping. Accuracy of the data in a specific cell is also included in the header information. Level III data have been digitized on a very limited basis and are organized in 7½' by 7½' cells and contains an elevation for each 1/2 second interval.

A cell of Level I data contains approximately 1,442,000 discrete Z points and represents a significant effort in collection and processing of the data. The data base contents were produced using two basic systems.

The first system uses existing topographic maps as the source from which a digital terrain elevation data matrix is derived for submission to the data bank. In 1964 DMA first used this system to digitize contour lines from repromats of topographic maps. The digitizing equipment recorded directly onto magnetic tape and had no on-line means to edit or make corrections to the data. Once recorded, the contour data were processed on a large computer to interpolate additional elevation points required to complete an elevation matrix. This elevation matrix was then used to direct a milling machine that produced three-dimensional terrain models from which plastic relief maps were formed. All imperfections due to the quality of the digital data were manually corrected on the terrain model using hand carving techniques. It became apparent that if ridge lines, valleys, streams, and some additional elevations were also digitized, the manual correction effort could be reduced. It was during this period that DMA received its first request for digital terrain elevation data. Since the data were not to be used for the purpose of producing three-dimensional plastic maps, we no longer had the option of correcting errors on the terrain model. Since the requirement now was a digital product, we had to improve the digital data and correction procedures. Subsequently, we implemented an operation in the production process called "pre-digital compilation." This operation has

been refined over the years and includes such tasks as sizing the sheet, adding supplemental information to effect better ties from sheet to sheet, as well as compiling ridge lines, valleys, streams, etc.

In the late 60's an expanded system was implemented which is still being used on a three-shift basis. It includes 10 digitizing stations, 2 plotters, and 2 computers with disks and magnetic tape units. The system software permits the operators to perform edit and correction tasks on-line which has greatly enhanced the production capability.

Presently a new system is being implemented that includes a scanner, 10 edit stations, and 5 computers to support the operation. This system will relieve the operator of the labor intensive task of tracing contours and provides an interactive edit and tagging capability. Tagging means adding the elevation value or feature identification to a line or point digitized automatically by the scanner.

The output from graphics-type digitizers provides a satisfactory digital data base product assuming that a topographic map of appropriate accuracy is available as the graphic source. When this is not the case, a photographic source must be used in a second or photogrammetric system.

The primary photogrammetric systems used by DMA are the AS-11 Analytical Stereo Instruments and the Universal Automatic Map Compilation Equipment (UNAMACE). Originally, these systems were used primarily for graphic mapping, however, during the past several years the production workload has shifted to digital products. Refinements have been and continue to be made to both hardware and software to improve the quality of data produced from these instruments.

The UNAMACE, which has been in production since 1967, has been refined in several ways. Automatic gain control was added to reduce the bias within the correlation loop. Profile line plotters were added to provide real-time display and a crude edit capability as the data are being compiled. The computer memory was expanded to accommodate many software improvements.

Presently, we are in the process of a major hardware and software upgrading. The significant benefits expected from this include increased reliability, maintainability, and a much higher confidence in the data produced.

Likewise, we are in the process of up-grading the computers and software on the AS-11 instruments. This will permit the collection of digital terrain elevation data directly from the system instead of digitizing the graphic portrayal now produced.

Although these new and upgraded systems will enable DMA to collect digital terrain elevation data of higher quality in a more responsive and efficient manner, it leaves us with another problem. As one might suspect, the quality of data generated during the past 15-year period varies considerably. Each refinement improved the quality to some extent, however, the quality required by the data base users has become more stringent. Data that satisfied yesterday's requirements will not meet today's. Approximately nine million SNM of data were produced from map sources in formats or on datums not compatible with the current data base standard. In many of these geographic areas there are current valid requirements for an improved digital product. DMA has implemented a conversion program to upgrade the previously digitized data to handle this situation. Typically, this involves evaluating the accuracy of the source map from which the data was derived, verifying the original digital data stored on magnetic tape, performing coordinate transformations, edge matching, merging corrections, determining the accuracy of the revised data, adding header information, and performing quality control checks prior to submission to the data base.

The man-hours and computer time currently expended to produce a typical cell of Level I Terrain Elevation Data using the three sources described is shown in Table 1. As one can see, it is labor intensive and consumes a vast amount of computer time. For these reasons, DMA has a continuing effort to streamline compilation, digitization, and computer processing procedures.

The shift in production from graphic to digital products may not seem too difficult to many of you here today. But, training and maintaining a state-of-the-art workforce for a large digital production operation has proven to be a difficult and expensive task. Attempts to accomplish this goal continues by hiring additional professionals with data base management and structure, computer science, or related backgrounds and by providing university courses, on the job training, and unique system training to present employees.

This has provided an adequate yield of personnel to perform production tasks such as compiling, digitizing, editing, and to a lesser degree computer processing. It is still extremely difficult to hire or develop personnel with outstanding problem solving abilities who are capable of conceiving new and improved production techniques and procedures.

TERRAIN ELEVATION DATA LEVEL 1
PRODUCTION METHOD COMPARISON

SOURCE USED	MAN-HOURS	COMPUTER SUP HOURS (UNIVAC 1108)
PHOTOGRAPHY	286	24
TOPO MAPS	184	7
DIGITAL DATA (UPGRADE)	27	6.75