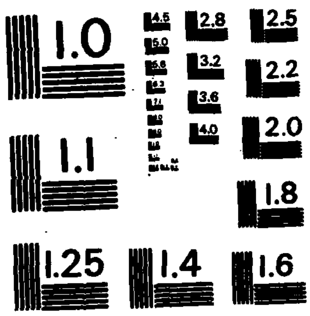
AD-A133 483 THE FUTURE IN TERRAIN ELEVATION DATA PROCESSING AT THE DEFENSE MAPPING AGENCY(U) DEFENSE MAPPING AGENCY WASHINGTON DC R B EDELEN AUG 83 1/1

UNCLASSIFIED F/G 8/2 NL

END


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

THE FUTURE IN TERRAIN ELEVATION DATA PROCESSING AT THE DEFENSE MAPPING AGENCY

Mr. Robert B. Edelen
Defense Mapping Agency
Washington, D. C. 20315

ABSTRACT

Since 1968 the Defense Mapping Agency (DMA) has been actively engaged in the production of Digital Terrain Elevation Data; initially to support plastic relief mapping, then to support "lines of site" studies, and more recently to support advanced weapons systems, simulators and navigational devices. With the increasing variety of users for Digital Terrain Elevation Data (DTED), the requirement for greater quantity, accuracy and diversity of DTED has likewise increased. To help meet these challenging production requirements of the future, DMA has awarded a major contract for development of the Terrain Edit System/Elevation Matrix Processing System (TES/EMPS). The TES/EMPS will provide state-of-the-art mini computers, array processors and specially developed software to perform complex data transformation, interpolation, merging and discrepancy detection functions. The TES/EMPS work stations, combined with mini computers and graphics processors, will provide advanced graphic displays and editing cababilities to perform interactive error correction, panelling and validation functions. All work flow through the system will be managed by the sophisticated job and file management software. The TES/EMPS will be installed at DMA in December 1983 and will perform all processing of DTED collected from photographic and cartographic sources.

INTRODUCTION

A major product of DMA is the Digital Elevation Matrix (DEM). A DEM refers to any set of elevation data recorded on a uniform grid; and consists of data defining the corners of a rectangular array, the grid spacing, and an array of elevation values. AT DMA, DEMs are produced in a variety of formats, coordinate systems and grid spacings to satisfy an increasing number of digital data users.

For those users who require digital data in a geographic coordinate system, the DMA-Standard format is used. DMA-Standard DEMs are produced in "cells" covering 1° X 1°, 15' X 15' or 7.5' X 7.5' with data spaced at 3" X 3", 1" X 1" or 0.5" X 0.5" intervals respectively at the Equator. For users requiring data spaced in meters on the ground, the UTM-Standard format is used where gridded data conform to the UTM coordinate system. DEMs may also be produced in local table coordinates for digital terrain modeling. Modified UTM or Geographic formats may be produced to satisfy a particular users needs. In all cases, the size of the data set and resolution of the data are determined by the primary users requirements.

BACKGROUND

In the late 1960's, a primary product developed at HTC was the plastic relief map. These were produced by drawing a heated plastic map down over a hand carved model of the earth's surface in a vacuum frame, thus forming the plastic relief map. Producing the carved

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) N/A	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Defense Mapping Agency Hydrographic/Topographic Center 6b. OFFICE SYMBOL (If applicable) TOT	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) 6500 Brookes Lane Washington, D.C. 20315	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Defense Mapping Agency 8b. OFFICE SYMBOL (If applicable) PA	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A
8c. ADDRESS (City, State and ZIP Code) Bldg. 56, U.S. Naval Observatory Washington, D.C. 20305	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO.: N/A PROJECT NO.: N/A TASK NO.: N/A WORK UNIT NO.: N/A
11. TITLE (Include Security Classification) The Future in Terrain Elevation Data Processing at DMAHTC	
12. PERSONAL AUTHOR(S) Robert B. Edelen	
13a. TYPE OF REPORT Final 13b. TIME COVERED FROM ______ TO ______ N/A	14. DATE OF REPORT (Yr., Mo., Day) August 1983 15. PAGE COUNT 8
16. SUPPLEMENTARY NOTATION 6th International Automated Cartography Symposium 17-21 October 1983 Ottawa, Canada	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	Image Manipulation Station Sensor Image Simulator TES/EMPS
08	02		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Since 1968, the Defense Mapping Agency Hydrographic/Topographic Center (HTC) has been actively engaged in the production of Digital Terrain Elevation Data; initially to support plastic relief mapping, then to support "lines of site" studies, and more recently to support advanced weapons systems, simulators and navigational devices. With the increasing variety of users for Digital Terrain Elevation Data (DTED), the requirement for greater quantity, accuracy and diversity of DTED has likewise increased. To help meet these challenging production requirements of the future, HTC has awarded a major contract for development of the Terrain Edit System/Elevation Matrix Processing System (TES/EMPS). The TES/EMPS will provide state-of-the-art minicomputers, array processors and specially developed software to perform complex data transformation, interpolation, merging and discrepancy detection functions. The TES/EMPS work stations, combined with minicomputers and graphics processors, will provide advanced graphic displays and editing capabilities to perform interactive error correction, panelling and validation functions. All work flow through the system will be managed by the sophisticated job and file management software. The TES/EMPS will be installed at HTC in

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☒ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Robert B. Edelen	22b. TELEPHONE NUMBER (Include Area Code) (202) 227-2609 22c. OFFICE SYMBOL TOT

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE. UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

Block 19. ABSTRACT Con't.

December 1983 and will perform all processing of DTED collected from photographic and cartographic sources.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

model of the earth's surface was a very time consuming and costly process involving many labor intensive tasks. To improve the process of generating these terrain models, DMA initiated R&D efforts aimed at digital collection of terrain information which, in turn, would support automatic production of terrain models.

In 1968, DMA procured the Digital Graphics Recorder (DGR) for digitizing contours from existing map manuscripts, and developed software for interpolating DEMs from the contour data. In the same timeframe, the Universal Automatic Map Compilation Equipment (UNAMACE) was developed to automatically generate DEMs from stereo photography. The original intent of these DEMs was for driving a milling machine for producing terrain models. However, the desirability of the DEM soon overshadowed the plastic relief map as a major product of the Defense Mapping Agency. As digital processing capabilities increased, so increased the demand for greater quantity, accuracy and diversity of DEM products. DEMs became highly desirable for such applications as: quantity determinators for engineering, slope analysis for cross country movement, contour, perspective scene and shaded relief generation for mapping, lines of site analysis for communications, scene generation for simulators, and guidance systems for advanced weapons. As requirements for DEMs increased, the production capabilities at DMA to meet these requirements, also increased.

PRESENT PRODUCTION SYSTEM

DATA COLLECTION

Data is collected at DMA on one of three collection systems; the Automatic Graphic Digitizing System (AGDS), the Upgraded UNAMACE, and the Pooled Analytical Stereo System (PASS).

AGDS. The AGDS is a fully integrated manuscript digitizing system consisting of a flatbed laser scanner that collects contours, drains, ridges, lakes and other supplemental information in raster form at a resolution of 0.001". After scanning, the data is vectorized, then edited and tagged in vector form prior to post processing into DEM formats.

Upgraded UNAMACE. The Upgraded UNAMACE is a photogrammetric collection instrument that automatically correlates stereo photography and collects data in a uniform matrix in a local orthogonal coordinate system, with minimum operator intervention. Limited editing may be performed on the Upgraded UNAMACE prior to post processing.

PASS. The PASS is another photogrammetric collection instrument used to collect data in a more interactive environment. Data collected with the PASS consists of Non-Uniform Matrices in profile form, geomorphic data (drains and ridges), lakes and double line drains, and control points. Like the UNAMACE, data may undergo limited editing prior to post processing into DEM formats.

POST PROCESSING

Post processing of DTED refers to all processing of data between collection and output as verified user specified products. Post processing occurs as a series of independent batch processes on 2 UNIVAC 1100/81 mainframe computers. These processes include the contour to grid interpolation functions for AGDS vector data, coordinate transformation and interpolation functions to transform data between local table, geographic, local orthogonal and UTM coordinate systems, and data integration functions to produce standard DMA products or special user formats. Editing functions are also performed in batch mode to remove anomolies and discrepancies in the data, perform hole fill operations, detect and remove noise in the data, and perform paneling operations to insure a smooth continuous surface between data sets. For verification throughout the post processing phase, a variety of plot files are generated for offline plotting on raster and vector plotting systems; these include profile plots, convolution or edge enhanced plots, contour plots, grey scale and shaded relief plots. Control point analyses are also performed to insure the accuracy of the final product.

VALIDATION AND QUALITY CONTROL

To insure the quality of the data produced at HTC, the Image Manipulation Station (IMS) and the Sensor Image Simulator (SIS) are employed. These systems provide the capability of generating advanced image displays for viewing DEMs prior to insertion into the DMA data bank or delivery to digital data users.

DEFICIENCIES IN THE CURRENT SYSTEM

DMA has in place the collection systems, and validation and quality control systems capable of meeting future DTED production requirements. However, deficiencies exist in post processing that must be addressed to satisfy those requirements. Problems (such as the response time associated with batch processing which often requires a 24 to 48 hour waiting period to review the results of an edit process, only to find that a keypunch or tape error aborted the run) severely affect throughput requirements. Limitations associated with the current plotting capability also affect throughput. When errors not detected on existing plots appear in a quality control system, the data set must be returned to post processing for correction; thus disrupting production. There are other deficiencies associated with production flow, file handling, editing procedures and processing algorithms which cause post processing in a batch environment to severely impact production.

TES/EMPS - THE FUTURE IN DTED PROCESSING

The previous sections have described the evolution of both the requirements for DTED and the current methods to produce it. As with any evolutionary process, piecemeal requirements were met with piecemeal solutions that were minimum cost modifications of existing capabilities. Often these solutions were mandated to utilize existing equipment. Experience has shown that such constrained Darwinian systems may minimize incremental costs, but generally at the expense of both total system capabilities/effectiveness and operation costs. Such production systems seem to agonizingly crawl to untenable positions, burdened by untractable loads, achieving only expensive mediocrity.

The TES/EMPS procurement at once revealed the potential benefits of a systems approach to expanding requirements beyond all expectations (anticipated, and yet unspecified). The subheadings of this section document the chronological steps that have been followed to develop a DTED system that not only meets today's processing requirements but is also guaranteed to cost-effectively expand in the future. The first subsection summarizes the system processing requirements. The second subsection covers design issues and objectives that are explicitly detailed and used to shape the design philosophy presented in the third subsection. The hardware design based upon this derived philosophy is covered in the fourth subsection. The final subsection completes the development cycle, summarizing the final systems operations characteristics.

System Requirements: Goals to Grow On

The TES/EMPS will perform all processing of digital elevation data from photographic and cartographic sources - from collection through output as verified digital elevation products. The TES/EMPS will address for the first time in a single integrated system the seven primary functions required in production processing of DEM data:

(1) Edit anomalies and discrepancies
(2) Convert contour data to matrix data
(3) Transform and interpolate DEMs to other coordinate systems
(4) Merge DEM's into product formats
(5) Edit and verify product DEMs
(6) Perform File and Job Management functions
(7) Perform rigorous quality control.

The TES/EMPS system was specified to be an integrated system composed of off-the-shelf, commercially available computers and peripherals of modern design, proven system software, appropriate interactive graphics software, and specific applications software. The unique requirement with potentially the largest production payoff is for an integrated job (or DEM project) management approach that optimizes equipment utilization to achieve the throughput rates mandated by the DMAHTC data user community.

Design Objectives: Guidance From the Past

Analysis of the requirements in light of previous production system acquisition experience leads to design objectives. The purpose of developing explicit design objectives, separate and distinct from design requirements, is to maximize system applicability; not only at time of delivery, but also for the entire working life of the system. Further, the disappointments and frustrations encountered in previous developments can be minimized, if not avoided.

The processing of digital elevation data to address all seven of the functions listed in the previous section requires the marriage of an extremely capable background processing system with an interactive processing system linked to a common data base and function set.

The TES/EMPS requirements are further constrained by four additional "production plant" considerations: reliability, maintainability, implementation risk, and expansion potential. Reliability, risk reduction and growth are the driving forces behind the DMAHTC requirement for use of off-the-shelf, commercially available components of modern design. Maintainability is achieved in three ways: good design, experienced maintenance personnel, and availability of spare parts. The risk level for the design and implementation methodology of a project with the scope of TES/EMPS is a critical issue. The magnitude of cost, production workload, and system effectiveness demands that a low risk approach be selected.

The observed growth in requirements for DTED, from both increased demands resulting from current applications and new applications (anticipated and unexpected), strongly points to TES/EMPS expansion. The expansion capability must address not only increased throughput, but also increasing sophistication of processing.

In summary, the key issues and objectives of the TES/EMPS design are:

- Extensive background processing capability
- State-of-the-art interactive graphics
- Integrated data bases and processing functions through a common file management strategy
- Sophisticated job management for optimal resource utilization
- High performance
- High system reliability
- Continuing system maintainability
- Low-risk implementation
- Extensive, low-cost, and long-term expansion capability

Design Philosophy: A Roadmap to Success

The system requirements and design objectives form a firm foundation upon which to build the high throughput production system desired.

Intergraph Corporation is one of the leading manufacturers of Computer Aided Design and Computer Aided Manufacture (CAD/CAM) Systems in the world. For interactive mapping applications, Intergraph is the leader.

A majority of the capabilities required for TES/EMPS are currently available in Intergraph systems. The TES/EMPS hardware requirements match closely with Intergraph hardware currently in production and use. New items brought into production by Intergraph in 1983, in combination with previous production equipment, will satisfy all of DMA's hardware requirements. Many software requirements are met by Intergraph's base level graphics and data base facilities contained in the Interactive Graphics Design Software (IGDS) and Data Management and Retrieval System (DMRS). Many unique DMA DTED processing functions are also contained in existing DMA production programs and other vendor software.

With this background, the lowest risk, lowest cost design philosophy, or technical approach to achieve a fully responsive, high performance system is built around the following critical design features:

- Maximum use of off-the-shelf hardware and software concepts
- Use of off-the-shelf government and industry application software and algorithms
- Integrated systems design that minimizes special or new software, algorithms or data formats

These critical design features will insure the final system has:

- maximum reliability
- assured maintainability
- lowest equipment cost through minimum R&D
- easy integration of advances in the commercial sector
- highest assurance of system growth potential
- minimized dependence upon unproven algorithms

Hardware Design: A Basis for Achievement

Analysis of the DMA DTED processing requirements show that they logically fall into three major categories: Interactive, Batch and Production Control Processing. The interactive processing includes quality control, data set merging, paneling and error correction. All processes, experience has shown, require a man in the loop for successful performance. The batch processing requirements include input/output operations, coordinate transformations, format conversions (such as, contour-to-grid), proof plot preparation, anomaly/discrepancy detection and other automated quality control aids. In general, these are fully automated CPU intensive background processes. The production control processing contains both fully automated tracking and scheduling operations, as well as interactive capabilities for system work assignments, status reporting and work flow control.

The basic hardware components of the TES/EMPS are the VAX 11/780, the workstation, the File Processor, the Graphics Processor, the Banded Vector to Raster Converter (BVRC) and Internet. These major components are supplemented with three billion bytes of mass storage and a full complement of the usual peripherals; line printers, tape drives, plotters, etc. The TES/EMPS will use three of Digital Equipment Corporation's 32 bit Vax 11/780 CPU's. Each of fourteen TES/EMPS workstations will be equipped with one 19" color display and one 19" black and white display, both with a resolution of 1280 by 1024 picture elements. The color display will be supported by 16 planes of refresh memory and will selectively display 256 grey scales or 256 levels of intensity for each color; red, green and blue. The Graphics Processor has been added to assume the background computational load. This 64 bit, programmable array processor, as a pipeline unit, is designed to operate in parallel with the central processor. The BVRC performs a high-speed vector to raster conversion enabling the plotter to operate at maximum speed. The File Processor is an intelligent disk controller which scans a disk at rotational speeds, analyzing and transferring to the Central Processor only the data that meet desired search criteria. This search function represents a second critical burden removed from the Central Processor, to enable the overall system to match the users' design pace. Internet is a local area CPU network for intersystem file access and transfer.

Two Intergraph 780 Data Processing Systems, connected to 12 Intergraph graphics workstations, will form the hardware backbone of the terrain editing system. Each Data Processing System will be equipped with two graphics processors. A third Intergraph system, with additional workstations, will be dedicated to control functions within TES/EMPS. This system will manage the project queue, parceling out jobs to the other systems, and will manage operations information and perform a large part of the matrix processing to support terrain editing and analysis. The third system will perform batch matrix processing and plot preparation work with the assistance of another graphics processor and two BVRCs, respectively.

Operational Characteristics: Realization of a Goal:

The following example scenario provides insight into the flexibility and power available for total DTED production processing with implementation of the TES/EMPS design.

Data enter the system via magnetic tape and are placed in mass storage by File Management. Based upon Production Manager Job Supervisor inputs, the Job Management subsystem creates a job step sequence and schedule.

Based upon the job step sequence, the Job Management subsystem directs the pre-edit software to acquire the data files via File Management and processes the data. The pre-edit software produces any required plots. Any background matrix processing is completed on an available VAX, as required for a given task. Upon completion, the data are transferred over the interprocessor communications link to the File Management subsystem on one of the edit system VAX's . Job Management controls this transfer and selects which edit VAX is to receive the data based upon resource availability. The data are entered into the edit VAX's mass storage by the edit VAX's File Management subsystem. Once the assigned editor selects the edit job step for these data from his work queue, the DEM Edit applications software uses File Management to access the data. Based upon editor commands, the DEM edit software establishes the type of data displays (either vector or image) most useful for the assigned edit functions. The transmission rates for the image format edit displays are assured through utilization of Intergraph's parallel I/O interface to the edit station. Real time three-dimensional rotation, zoom and pan of the terrain presentations (from 2 to 8 views) are available so that editors will be able to effect changes dynamically and see the results immediately. Project continuity will be vastly improved, with dramatic increases in accuracy and productivity. The decrease in feedback time alone is expected to provide a strong boost to employee job satisfaction. Upon completion of edit, the corrected data files are transferred back to VAX 1 via the interprocessor communication link. As appropriate, either post or matrix processing (for coordinate transformation) is scheduled to complete processing of the active files. At completion of this and any other edit job steps specified by the Production Supervisor and scheduled by Job Management, the data are stored on VAX 1 mass storage by File Management. Job Management schedules and accomplishes the generation of plot tapes, quality control sessions at the Production Supervisor's station, output via the I/O processor of archive tapes, and finished DMA product tapes along with job schedules and status reports.

END

DATE
FILMED

10 83

DTIC