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COMPUTER GRAPHICS FOR THE ARMY.(U)
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COMPUTER GRAPHICS FOR THE ARMY (U)

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I. INTRODUCTION

General

Computer Graphics for the Army, as described in this paper, are the products of a trilateral cooperative research project involving the U.S. Military Academy, West Point, New York, the Defense Mapping Agency (DMA), Washington, D.C., and the U.S. Army Engineer Topographic Laboratories (ETL), Fort Belvoir, Virginia. Many other such research efforts are underway throughout the Department of Defense. The intent of this paper is to focus on the work done at West Point during the past 2-1/2 years. This project is referred to as the DMA/ETL Research Project.

The West Point Computer Graphics Laboratory (CGL)

This facility, located in the Department of Geography and Computer Science, has been in full operation for the past two academic years. It provides an excellent "state of the art" environment for individual cadet and faculty projects as well as for funded research efforts in computer graphics. The hardware configuration combines the power of the Academy's main frame computer (UNIVAC-1100/12) with the responsiveness of a minicomputer (PDP-11/40) and the dedication of a number of different microprocessors (AM-100, LSI-11, IMSAI-8080 and others). The PDP-11/40 is currently being replaced by a VAX-11/780 minicomputer. The portion of the laboratory most directly related to the work on this project is shown in figure 1.

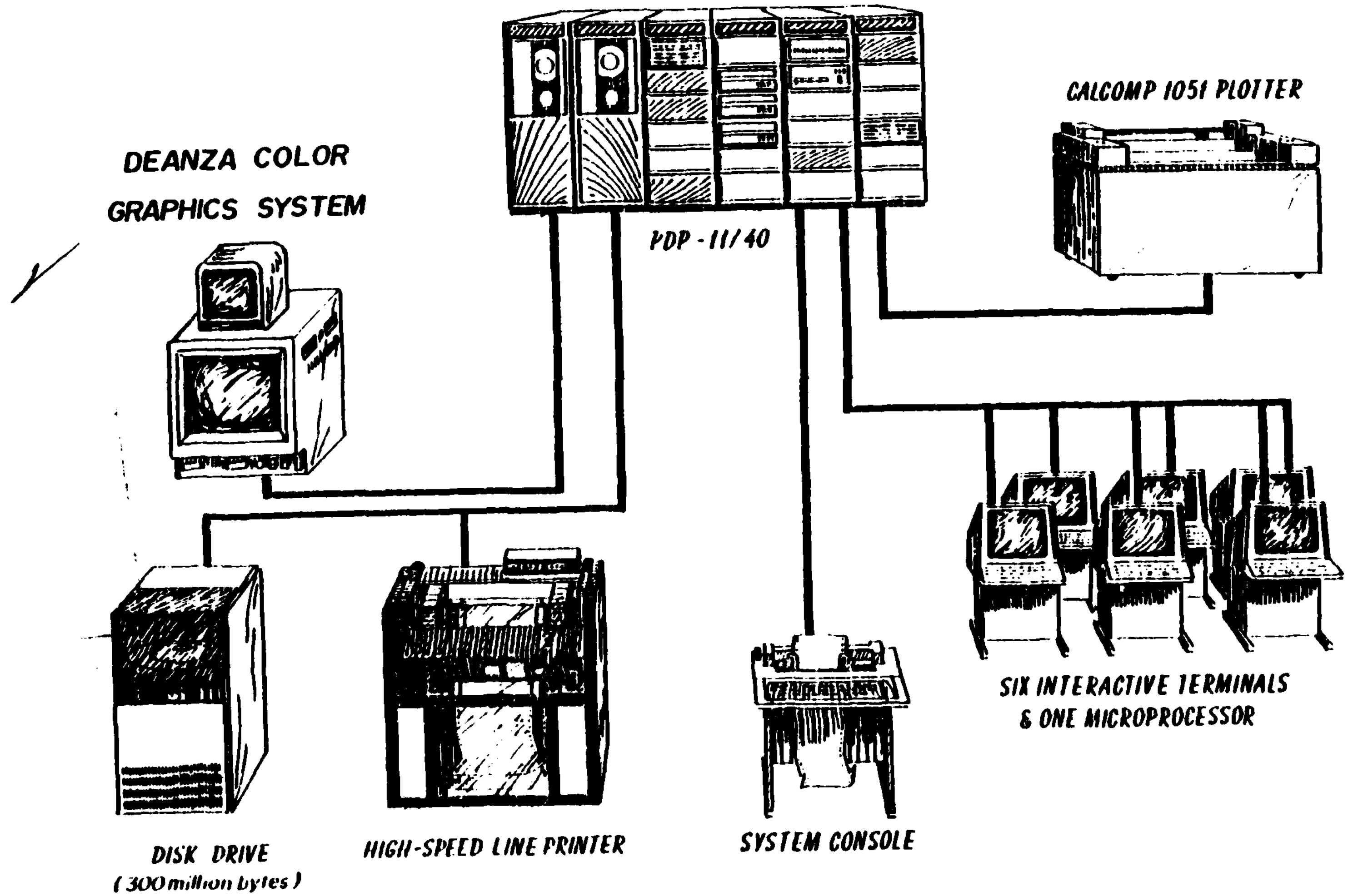

FIGURE 1. Computer Graphics Laboratory Equipment Supporting DMA/ETL Research Project.

II. THE DMA/ETL RESEARCH PROJECT

Objectives

1) Receive experimental graphics software packages from the ETL and make all modifications to bring these programs to a totally operational status at West Point.

2) Receive a DMA special data base of West Point and vicinity and transform it to a disk resident file in the CGL which can be efficiently accessed by the ETL software.

3) Link the software (1) and the data base (2) to develop computer-generated views and overlays of the West Point Military Reservation. Included within the area of coverage is Camp Buckner, the cadet field training area located approximately 10 miles west of the U.S. Military Academy.

4) Conduct an accuracy study of the West Point digital data base to include a ground truth survey of a portion of the digitized area. The goal of this study is to determine the minimum essential data accuracy for various Army applications.

5) Incorporate computer-generated graphics into the cadet field training program during the summer months and into the academic curriculum as appropriate.

6) Evaluate the military utility of these graphics and report on all findings.

Status

Substantial progress has been achieved in the generation of four basic graphic products. These include the line of sight profile, line perspective view, line oblique view and shaded perspective view. The ability to generate these graphics is not a new concept. The significance of the research at West Point is that the generation of these graphics has been tailored for Army needs. The next chapter will provide a look at each of these four packages with a focus on the final product, the user's prompts and on major software modifications.

Progress has also been accomplished on the accuracy study and on the objective to implement this technology into the cadet field training program. The results of this work are described in Chapters IV and V respectively.

III. APPLICATIONS SOFTWARE

General

The software packages used in support of the DMA/ETL research project were developed in the Automated Cartography Branch, U.S. Army Engineer Topographic Laboratories. This branch is headed by Mr. Howard Carr. The developer of the basic concepts and programs was Mr. James Jancaitis.[1]

Line Of Sight Profiles

Although clearly the simplest of the four programs, the ability to generate a profile between any two points, in less than two minutes, is a valuable tool for the soldier. In fact hand generation of these profiles, which could take 20-30 minutes, is often necessary.

As seen by the prompts in figure 2, the user input parameters are minimal. The resulting product (fig. 3) is a cross-sectional view of the intervening terrain. The accuracy and speed of this plot varies as a function of the number of points sampled.

Changes to this software included modifications of all interactive prompts, overlaying the task to permit either TEKTRONIX screen (CRT) or CALCOMP plotter output and the implementation of SUBROUTINE CARTO which opens the user-specified unformatted random access data files. Upon receipt of a new data base, the user need only add the name and characteristics of that data base to CARTO, and the remaining software can access it immediately.

```
Enter "1" for TEKTRONIX output, or
      "2" for CALCOMP output

1

Enter "1" for West Point,
      "2" for Fulda Gap, or
      "3" for Cache data base.

1

Enter the left side coordinates.
Example: NB50003000

UA76417576

Enter the right side coordinates.

UA77637782

Enter height above ground at
left end and right end (meters).
Example: 2.0,2.0

2.0,2.0

Enter # pts along LOS - INTEGER

100

Enter vertical scaling factor

1.5
```

FIGURE 2. Prompts and Responses for Line of Sight Profile at Figure 3.

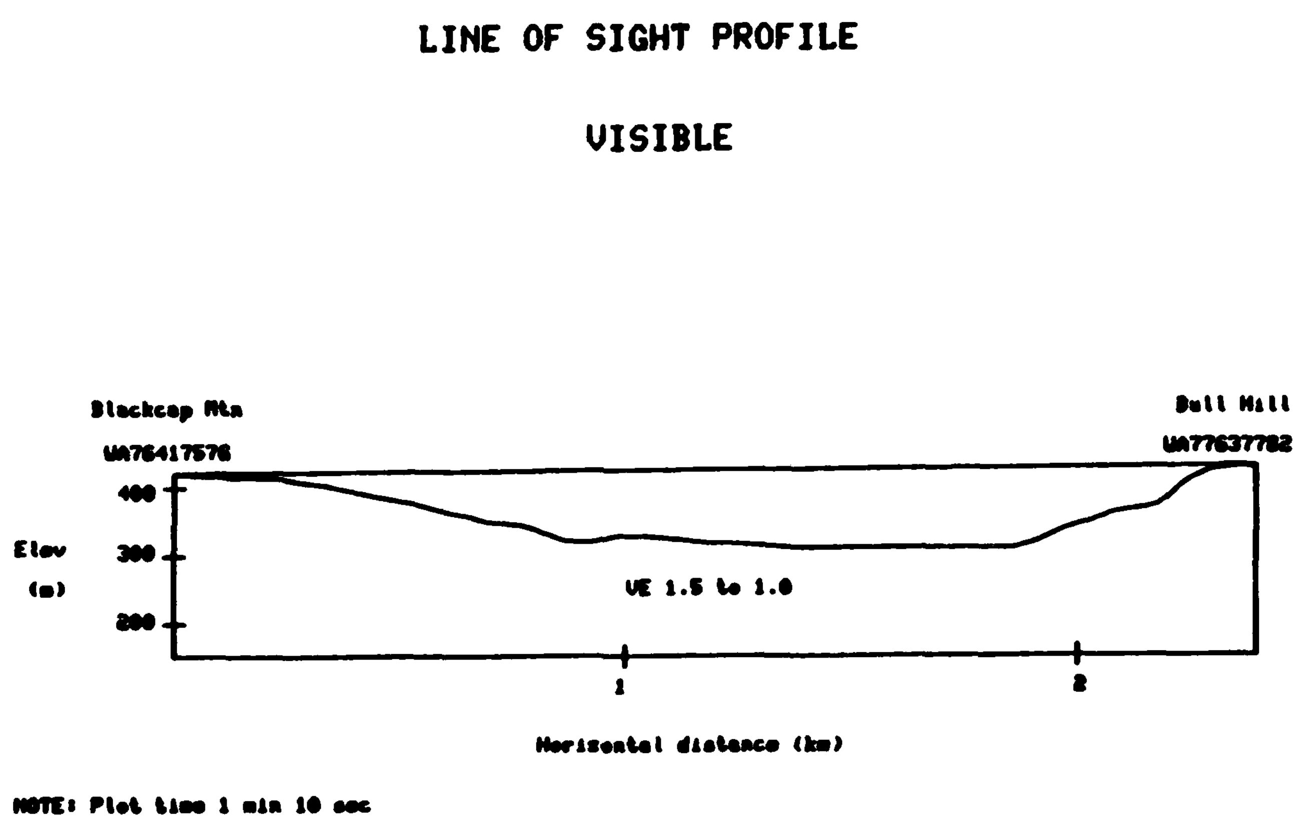

FIGURE 3. Line of Sight Profile.

Line Perspective Views

The following (fig. 4) is an illustration of the prompts and responses to produce a line perspective view. In approximately six minutes a three-dimensional graphic, such as the example shown in figure 5, is generated.

In addition to modification of the input prompts and inclusion of SUBROUTINE CARTO, a new subroutine was developed to facilitate efficient generation of perspective views. This subroutine, called PWINDO, accesses elevation data from disk conforming to a pie-shaped subarea and stores this data in core. If the area being viewed is too large to fit in core at one time, this routine will read what it can and then trigger successive iterations until the entire perspective view is completed. In conjunction with PWINDO, SUBROUTINE ALTP was developed to extract the correct data values from the core buffer and compute the required elevations.

```
Change plot size?  Any response
other than YES causes the final
plot dimensions to be 14" wide
and 10" high.

NO

Change viewing parameters?  (YES or NO)

YES

Enter the INTEGER # of radials (75 max).
Example: 75

75

Enter the INTEGER # of points per
radial (199 max).
Example: 100

100

Enter how far you can see (Km).
Example: 3.5

6.2

Enter the vertical exaggeration.
(the example below implies 2:1)
Example: 2.0

1.5

Enter "1" for West Point(1),
      "2" for Fulda Gap,
      "3" for Cache,
      "4" for West Point(2)
      "5" for West Point(3), or
      "6" for West Point(4).

5

Enter square ID and 8-digit
coordinates of the southwest corner
of the viewing window (oblique view)
or the viewers position (persp. view).
Example: NB50003000

UA83000000

Input azimuth (deg) and height (ft).

225.,500.
```

FIGURE 4. Prompts and Responses for Line Perspective View at Figure 5.

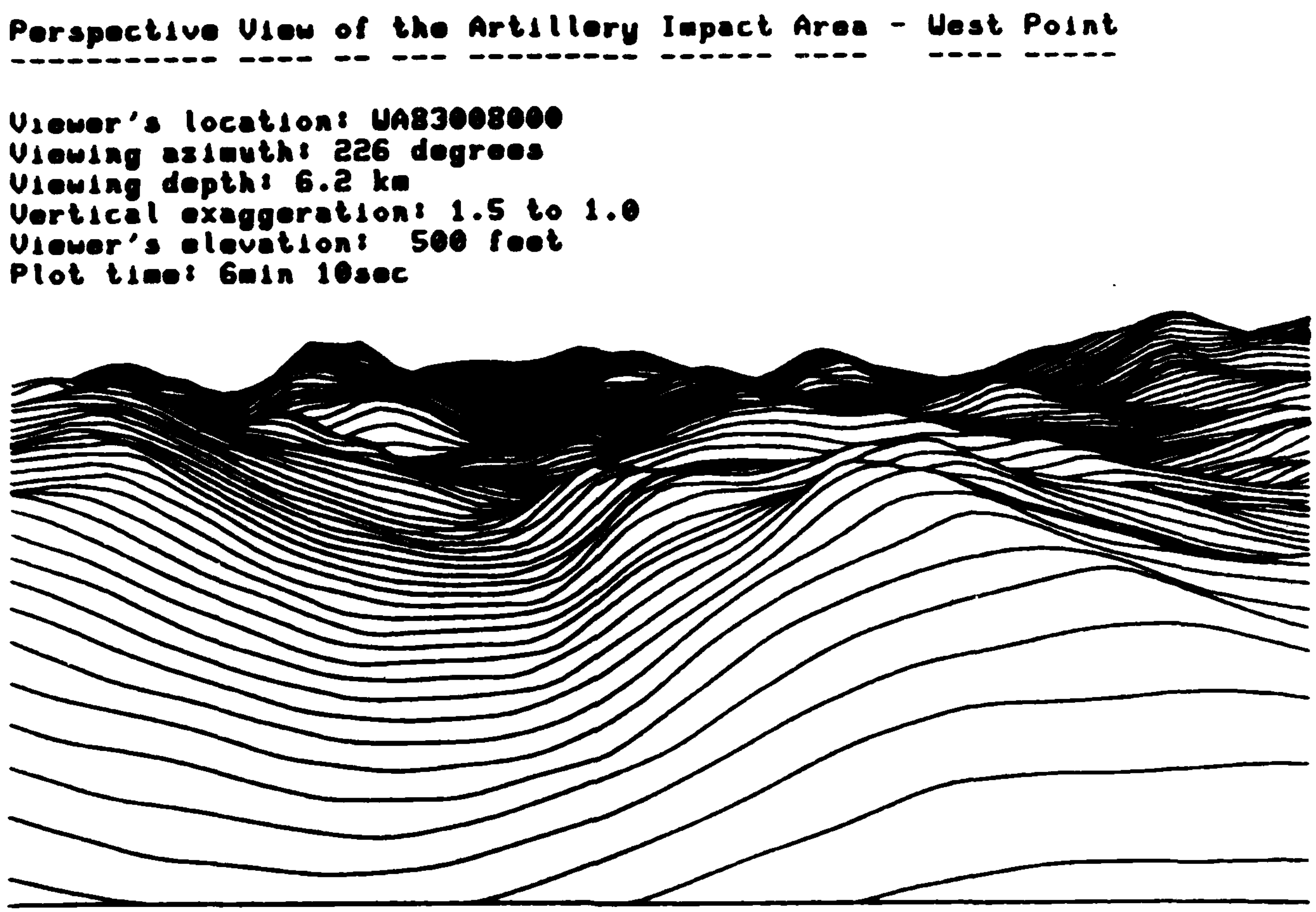

FIGURE 5. Line Perspective View.

Line Oblique Views

Experimentation with this form of terrain representation during the 1979 Cadet Field Training Program indicated widespread potential military applications, especially for large areas. Refer to figure 6 for the sample prompts and figure 7 for the resulting sample graphic.

Modifications of this software are similar to those required for the line perspective case. The program structure was first overlaid to allow for greater core data arrays. The interactive prompts were changed. SUBROUTINE CARTO was implemented, and the program was configured to generate either TEKTRONIX or CALCOMP output. Substantial effort was also devoted to improving the internal documentation and efficiency of the source code.

```
This program will generate oblique views of West Point
and Vicinity, Fulda Gap or Cache, Oklahoma.  Enter GO to
continue or STOP to terminate.  Upon completion of plot,
hit RETURN to return to this prompt.

GO

Enter "1" for West Point(1),
      "2" for Fulda Gap,
      "3" for Cache,
      "4" for West Point(2)
      "5" for West Point(3), or
      "6" for West Point(4).

5

Enter square ID and 8-digit coordinates of the
southwest corner of the viewing window (oblique view)
or the viewers position (perspective view)
Example: NB50003000

WA84008000

Enter width and depth of area being viewed (km).
Example: 5.0,5.0

5.,5.

Enter # of profiles to be plotted (INTEGER 199 max)
Example: 175

100

Enter the vertical exaggeration.
(the example below implies 2:1)
Example: 2.0

1.5

Enter the aspect angle and viewing azimuth (deg)

40.,226.
```

FIGURE 6. Prompts and Responses for Line Oblique View at Figure 7.

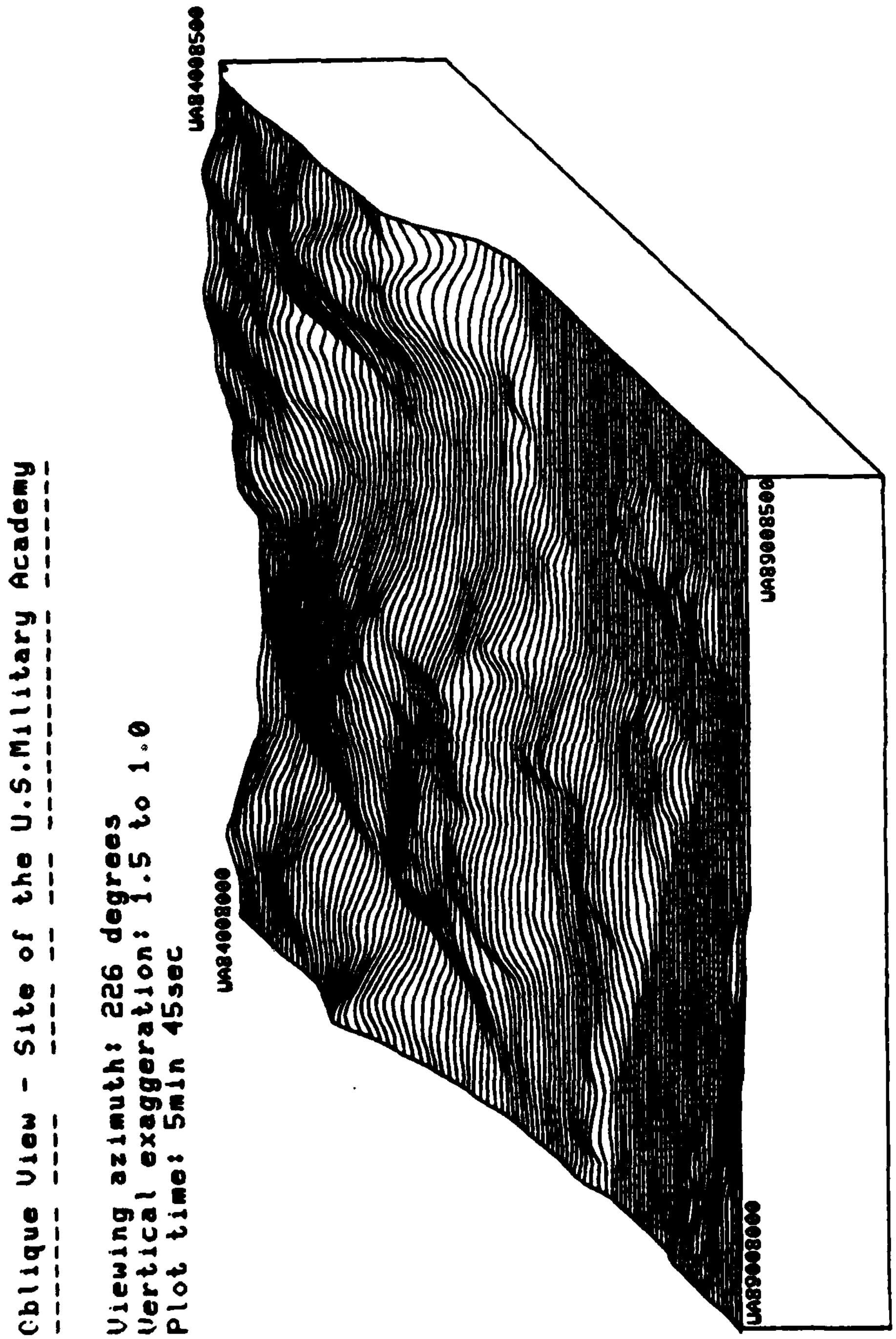

FIGURE 7. Line Oblique View.

Shaded Perspective View

This software package represents the first major accomplishment involving color graphics within the CGL. The preliminary successes are very promising. Originally, the shaded perspective software was written at the ETL by Mr. Cyrus Taylor[3] and made available to West Point in August 1979. Its output was a black-and-white image produced on a VERSATEC dot matrix plotter. Modifications at West Point included code simplifications and internal documentation, task overlaying, the inclusion of SUBROUTINEs CARTO and PWINDO, the development of the prompts illustrated in figure 8 and the addition of synthetic color to generate the graphic shown in figure 9. Current efforts are underway at both the ETL and West Point to further simplify the production of these images. The goal is to retain the current detail while reducing the image generation time to be compatible with the line perspective software. Additionally, with the assistance of Mr. Robert Getz, the department illustrator, and Cadet Joseph Hafeman, who is conducting graded research in computer graphics, a series of color tables are being developed to increase the realism of the synthetic color process.

```
Enter "1" for West Point(1),
      "2" for Fulda Gap,
      "3" for Cache,
      "4" for West Point(2),
      "5" for West Point(3), or
      "6" for West Point(4).

5

Enter square ID and 8-digit coordinates
of the southwest corner of the viewing
window (oblique view) or the viewers
position (perspective view).
Example: NB50003000

WA83008000

Enter viewing azimuth (degrees) and
height above ground (feet).
Example: 226.0,1000.0

226.,500.

Enter how far you can see (km).
Example: 6.2

6.2

Enter # radials, # points per radial
and # pixels per column (INTEGERS).
Example: 512,150,480

512,200,480

Enter the vertical exaggeration.
(the example below implies 2:1).
Example: 2.0

1.5

Enter the vertical and horizontal sun
angles (degrees).
Example: 45.,90.

45.,315.
```

FIGURE 8. Prompts and Responses for the Shaded Perspective View at Figure 9.

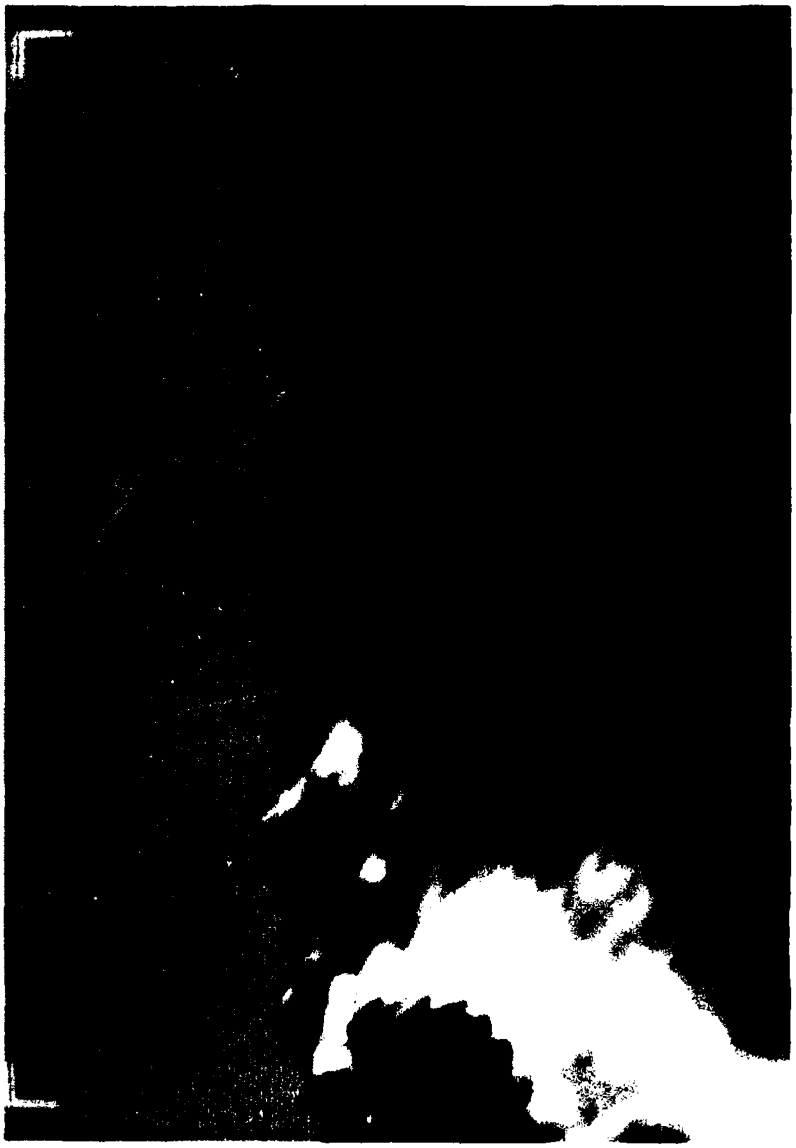

FIGURE 9. Shaded Perspective View.

IV. DATA BASES

Acquisition

Data bases for this research effort are provided by the DMA. All current applications have utilized DMA special data of Fulda Gap, Germany, and West Point, New York. The data have been reprocessed into polynomial coefficients by the DMA Aerospace Center (DMAAC) and delivered to West Point encoded in 8-bit ASCII format. This system has proven to be quite convenient when transferring data from a 36-bit main frame computer to a 16-bit minicomputer. Additionally, the polynomial coefficients appear to afford an advantageous compaction benefit plus a rather accurate means of computing intermediate elevations. Efforts are underway to experiment with DMA source tapes directly. This may eliminate the requirement to reprocess. In conjunction with these tests is the overall program to study data base accuracy, whether the data is represented by polynomial coefficients or strictly as nodal elevations.

Accuracy

Two major questions exist regarding digital data when one considers computer graphics for the Army. The first is, how well do data bases of various intervals and characteristics represent the terrain in question and second, what is the minimum accuracy required for the particular application in question? The accumulation of statistics to answer both questions is being presently undertaken at West Point. In cooperation with the DMAAC, the West Point data base has been reprocessed into eight successively thinner polynomial representations. Computed elevations are being compared to surveyed elevations to observe accuracy degradation as a function of thinning when polynomials are used. Elevations for the same locations will be computed from the source data base and compared as well. Additionally, graphics of the area will be generated utilizing each of the data bases, and the resulting products will be compared with the actual terrain. This effort is expected to be completed by June 1981. The table on the following page (fig. 10) is a sample of the information that has been gathered thus far.

UTM COORDINATES	SURVEY	ELEVATIONS (FT) INTERPOLATION 1:24000 MAP	DMA DATA BASE(1) (12.5m / NFF=4)	DMA DATA BASE(2) (25.0.m / NFF=4)
UA85038279	575.40	570.00	576.80	576.70
UA85178286	554.60	550.00	548.70	547.40
UA85228291	528.40	530.00	527.70	527.30
UA85348280	607.10	600.00	604.00	604.90
UA85458273	647.10	630.00	631.10	635.50
UA85488268	666.00	660.00	664.20	663.20
UA85538260	672.00	680.00	689.90	689.10
UA85578254	681.70	690.00	699.00	699.40
UA85658248	732.50	720.00	726.70	727.40
UA85668245	743.70	740.00	749.10	744.00
UA85658240	769.10	770.00	767.10	769.60
UA85648240	772.70	770.00	769.40	771.90
UA85208232	977.10	970.00	967.50	970.40
UA85158230	984.70	970.00	969.40	968.00
UA85188225	987.50	990.00	978.20	973.10
UA85208220	981.30	990.00	978.70	972.00
UA85198217	986.70	970.00	953.30	951.70
UA85148213	959.50	960.00	963.40	952.70
UA85138210	970.90	970.00	960.70	960.70
UA85098206	977.70	970.00	977.40	967.20
UA85058201	994.10	990.00	994.40	984.20
UA85038195	1002.20	1010.00	982.30	971.80
UA85018191	978.60	970.00	948.60	943.80
UA85028188	957.70	940.00	916.40	915.90
UA85038184	910.60	900.00	898.00	899.30
UA85088186	908.20	890.00	880.40	882.80
UA85098181	881.50	870.00	864.40	861.80
UA85118179	862.10	850.00	839.40	833.40
UA85608180	682.40	670.00	678.10	679.90
UA85828200	708.60	720.00	712.80	712.60
UA85798206	719.60	720.00	722.40	718.30
UA85838222	734.10	730.00	736.50	737.80
UA85788228	730.20	730.00	725.90	730.20
UA85698230	737.70	730.00	722.40	724.50

FIGURE 10. Quantitative Comparison of Terrain Elevations from Different Sources.

V. FIELD APPLICATIONS

General

During the summer of 1979 the class of cadets having just completed their freshman year spent approximately seven weeks in field training at Camp Buckner. During the last two weeks of the training program, computer-generated terrain graphics were incorporated into portions of the field training on a trial basis. These graphics were provided to the Artillery, Engineer and Infantry instruction committees.

Findings

Although the duration of this application phase was limited, a number of significant facts were determined.

1) The users of this technology must be educated on its application and potential before they can apply it properly. Merely showing examples of sample graphics does not sufficiently enable the users to intelligently request the exact graphics they need.

2) The data base will not provide the minute detail of actual slopes. This detail is not available on the source maps.

3) There is substantial need for graphics which are well labeled and which include cultural features.

4) The graphics are excellent tools which can be used to illustrate what is being portrayed on a 2-D topographic map. They leave a picture in one's mind which topographic map sheets do not often do. They are valuable aids for planning operations, and their potential utility in the teaching mode is limitless.

5) Oblique views are applicable to areas that are 4km square or larger. For areas of this size, they represent the terrain accurately; in fact, this representation proved to be a valuable asset to the Artillery training in particular.

VI. SUMMARY

Applications of computer graphics at Camp Buckner, utilizing the graphics packages discussed, will be conducted once again this summer. Emphasis will be placed on utilization of the graphics to stress key training objectives. Cadet Scott Keller is conducting a graded research project to support this effort.

Emphasis has already been placed on automatically labeling and overlaying all the computer-generated graphics. Actually, this problem has been partially solved but not yet implemented.

Contour plots with overlays, both raster and vector, and radar masking diagrams will be implemented in the near future.

As mentioned in Chapter IV, the data base accuracy study will continue for another year. Both DMA Standard and Special data bases with nodal spacing conforming to either the UTM or Geographic coordinate systems will be employed.

Color perspectives with a focus on near-real-time image generation will be stressed. The initial response to the color perspective views has been encouraging.

In conclusion, a number of computer graphics packages have been presented which are tailored for Army needs. The initial response to these products at West Point has been resoundingly positive. The tasks that remain are refinement, education, application and further refinement. If this approach is followed, computer graphics will play a significant role in the Army of the future.

VII. ACKNOWLEDGEMENT

The patience, generosity and continuous support rendered by both the DMA and the ETL is gratefully acknowledged.

A special word of thanks is due to Mr. James Jancaitis (ETL), Mr. Cyrus Taylor (ETL) and to Mr. Russell Gustin (DMAAC) for their personal contributions of time and effort.

Finally, Mrs. Jane R. Tosolini is to be thanked for reviewing and typing this manuscript.

VIII. REFERENCES

[1]Jancaitis, J. R., "Modeling and Contouring Irregular Surfaces Subject to Constraints," Final Technical Report No. ETL-CL-74-19 for U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, on contract DAAK02-73-C-0213, January 1975, 171 pages.

[2]Taylor, C. C., "Computer Generation of Shaded Relief Images for Cartographic Applications," Final Technical Report for U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, July 1979, 223 pages.

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