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Terrain Analyst Work Station (TAWS): 1AD After Action Report

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At the request of the 1st Armored Division (1AD), the Engineer Topographic Laboratories visited 1AD and demonstrated the Terrain Analyst Work Station (TAWS), demonstrated its capabilities, and provided products for 1AD's area of interest. This after action report describes the TAWS, its capabilities, and the training performed; and reports the comments provided by 1AD and others about the TAWS and products provided.

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PREFACE

The work reported herein was performed under DA Project 4A762707A855, Task C, Work Unit 00039, "Terrain Analyst Work Station" (TAWS).

The demonstration was performed in October 1985 under the supervision of Mr. Richard B. Marth, Chief, Geographic Support Systems Branch, Mr. A. C. Elser, Chief, Geographic Concepts Division, and Mr. Bruce K. Opitz, Director, Geographic Systems Laboratory, U.S. Army Engineer Topographic Laboratories (ETL).

An appreciation is extended to members of the TAWS team who played important roles in preparation for the TAWS demonstration – Carla Ennis, Victor Gonzalez, Elizabeth Porter and Mark Sither.

A special thank-you is extended to Ms. Martha Bishop, Ms. Marjorie Davis and Ms. Bonnie Turner of the ETL Security Office for assistance in shipping the classified data for the demonstration; to the Humphreys Engineer Center Support Activity (HECSA); and to Messrs. Larry Staley, Cedric Key, and James Burroughs, Terrain Analysis Center, ETL, for obtaining and reproducing Defense Mapping Agency (DMA) Tactical Terrain Analysis Data Bases (TTADB's).

Also, special thanks is given to the TAWS team's hosts, the officers and soldiers of the 1st Armored Division, the 518th Engineer Detachment (Terrain), and the 526th Engineer Detachment, VIIth Corps.

COL Alan L. Laubscher, EN, was Commander and Director, and Mr. Walter E. Boge was Technical Director of the U.S. Army Engineer Topographic Laboratories during the report preparation.

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INTRODUCTION

To fight and win the AirLand battle, the Army must field a combat force that can move quickly and lethally against the enemy. The speed and mobility of this force will depend in part on the availability of up-to-date intelligence information – information not only about the enemy, but about the terrain and environment as well. Combat commanders need to know as much as they can about the battlefield and need to get this information as quickly as possible.

At present, terrain and intelligence analysts manually assemble and analyze such information. Manual terrain analysis is a slow, tedious process at best. Producing a single tactical terrain graphic may require hours of labor from even the most highly skilled analyst.

Digital terrain data bases and automated terrain analysis techniques will help the Army meet the demand for quick, comprehensive information about the terrain. The Army has expressed its needs for digital terrain data to the Defense Mapping Agency (DMA) and plans to field the Digital Topographic Support System (DTSS) to exploit that data in the 1990's. The automated terrain analysis techniques to be employed by DTSS have already been successfully demonstrated in the laboratory on an interactive computer graphics system. Complex terrain products such as cross-country movement maps and cover and concealment graphics can be produced from prototype digital terrain data bases and can be done in a fraction of the time required by the unassisted analyst.

Since U.S. military commitments span the globe, it would be difficult (if not impossible) for DMA to provide the Army with digital terrain information for every area that may eventually be of strategic or tactical interest. Even if complete coverage of the earth were possible, data base users would still find gaps between these general digital sources and the actual lay of the land, particularly in the battlefield environments. Modern combat technologies can change the face of the battlefield, making terrain information that was accurate yesterday obsolete in a matter of minutes.

Today's terrain analysts, working with maps, charts, and other sources, must take such changes into account. Even after automation, troops in the field will still need to update and revise terrain data to reflect current conditions. The soldiers who man the topographic units of the future must also be equipped to create new terrain data bases should they be called upon to support combat operations in areas for which DMA data are not available.

PROJECT OBJECTIVES. In response to this need, scientists at the Engineer Topographic Laboratories (ETL) have assembled a Terrain Analyst Work Station (TAWS). This terrain analysis demonstrator will showcase computer-assisted techniques that will eventually enable Army terrain analysts to produce, update, and manipulate digital terrain data bases in the field. Although TAWS is essentially a laboratory system, the incorporation of its capabilities into the planned DTSS will help make that follow-on development a fully functional automated topographic support tool.

The primary function of TAWS is to perform data extraction, digitization, and mensuration; however, the work station also incorporates certain data manipulation and product generation capabilities. The system provides Army terrain analysts with the tools needed to 1. create topologically valid digital terrain data bases using monoscopic and stereoscopic, multisensor imagery, graphics, text, and other military geographic information data sources; 2. edit, update, revise, and intensify existing data bases; 3. merge data extracted from any of the data sources; 4. overlay features on digital elevation data; 5. manipulate, analyze, and display, in 2- and 3-D views, digital terrain data; and 6. generate and disseminate Army battlefield tactical decision aids.

To obtain user feedback on capabilities being developed and their manner of presentation, the TAWS capabilities would be demonstrated in garrisons and at field exercises as requested by interested Army elements. The soldiers participating in the demonstration would be trained in the operation of TAWS and be allowed hands-on experience with the equipment and software. Comments on the system and the demonstration preparation would be solicited from the soldiers after a week of operating experience under the supervision of ETL scientists and engineers. Comments made during and after the demonstration would be used to help guide TAWS and DTSS development.

HARDWARE. The TAWS incorporates off-the-shelf hardware and builds upon software techniques demonstrated in ETL research efforts. The TAWS computer is a 32-bit microcomputer with 4.0 megabytes of random access memory. It is supported by 264 megabytes of Winchester disk storage and a 9-track, 1600 BPI tape drive. The input and output devices consist of black and white and color graphics capability. An X-Y digitizing table provides the initital digital terrain data base creation capability. Existing terrain analysis products such as the Planning and Tactical Terrain Analysis Data Bases (PTADB's and TTA DB's) are digitized on the X-Y table to form a digital terrain data base. A Light Table Mensuration System (LTMS) is currently being integrated into TAWS for exploiting photographic imagery to generate and intensify digital terrain data. The update, edit, and intensification capabilities will be added to TAWS when an Analytical Stereo Plotter (ASP) with stereo superpositioning and profiling firmware is integrated into the system in the near future.

The Army-fielded MICROFIX system has been interfaced to the TAWS computer so that digital terrain products generated on TAWS can be distributed to units in the field who currently use the MICROFIX. Currently the TAWS-MICROFIX effort is in the developmental stage. Interfacing routines must be changed to take into account changes due to a new version of MICROFIX.

SOFTWARE. The TAWS software is an exploratory developmental effort that advances and refines basic research capabilities demonstrated at ETL. A Geographic Information System (GIS) designed for data base creation, analysis, and product generation comprises the majority of the TAWS applications software. The TAWS GIS physically consists of a data collection subsystem and a product generation subsystem. Both subsystems support specific analysis functions.

The data collection subsystem consists of photogrammetric, digitizing, and verification routines. Additionally, the data collection subsystem has the capability to read and extract information from certain digital sources and output in DMA-specified digital product formats. The photogrammetric routines enable the analyst to interactively compute the camera and control point parameters of selected imagery. With the digitizing devices (e.g. ASP, LTMS, X-Y Table), the analyst can digitize in any scale or orientation, and the size of coverage of each data base is also analyst-specified. The data are digitized in arc-node format. Primary attribute information is entered at time of digitization. Secondary or multiple attributes can be entered at any time subsequent to digitization. Editing of arcs, nodes, or attributes can be done either at the time of data entry or at a later time by querying the data base for a specific arc, node, or polygon, each of which is uniquely identified. Once digitization is complete, each feature in a manuscript can be topologically verified. The analyst invokes verification routines that check for various errors, including illegal or missing attributes, arcs, and nodes, duplicate or kinked arcs, and slivers and gaps. When completed successfully, the verification routines confirm that a topologically valid manuscript has been compiled.

The product generation subsystem receives the reformatted, verified data sets from the data collection subsystem. Additionally, several types of digital data can be directly read and incorporated into the product generation subsystem data bases. The product generation subsystem currently handles vector-formatted polygon data sets and will in the near future handle raster-formatted data. This subsystem consists of storage and control, analysis, and display and plotting routines. The storage and control routines provide an interface between the vector and raster analysis functions and the cartographic output functions. They also provide the capability to add to, access, and manipulate the map data sets. The product generation analysis routines perform a variety of functions ranging from calculating and outputting tabular information, such as descriptive statistics, reclassifying map information, to complexing or overlaying map data sets. The display and plotting routines produce user-oriented cartographic or display output on the CRT or plotting devices. Product generation is an interactive process on TAWS. The terrain analyst can create a product of interest or use predefined models to generate a product. Figure 1 is an example of an analyst-created concealment (Summer) product. Canopy coverages at operator-defined ranges were extracted from the date base and displayed. Figure 2 shows a cross-country mobility product for an M60 tank that utilized the Condensed Army Mobility Model System (CAMMS) routines. The CAMMS, a Waterways Experiment Station (WES) model, was installed on TAWS by WES and ETL scientists for AirLand Battlefield Environment (ALBE) demonstrations. The CAMMS determined speeds at which an M60 tank could move, given moisture conditions and a complexed map of soil, transportation, slope, vegetation, and obstacle factors.

Ancillary to the GIS, the TAWS supports specialized terrain analysis software used to generate intervisibility products for planning military operations. The intervisibility products are generated from digital elevation matrices compiled on TAWS from DMA Digital Terrain Elevation Data (DTED). Intervisibility products are used to determine areas that are visible, either optically or electronically, from a given site. They compensate for earth curvature and atmospheric refraction and optionally incorporate vegetation heights in the analysis. The TAWS intervisibility products include line-of-sight profiles and masked area plots. Examples of a masked area plot and perspective view graphics are shown in figures 3 and 4. The TAWS also contains a data base and associate applications routine of climatic and environmental information used to support the terrain analysis process.

SOFTWARE DESIGN. Although the basic applications software capabilities have been demonstrated in ETL research projects, integrating the component software into a developmental system is an effort of considerable magnitude and complexity. A number of design considerations had to be incorporated to coordinate and implement the software on TAWS. The development strategy employs current techniques of systems analysis such as following a top-down design, utilizing both manual and automated configuration management tools, and segregating the development, test, and user-accessed sectors of the system. The software design goals of TAWS are to develop a modular, portable, device-independent, and user-friendly system. To achieve the first goal, all software was segregated into functional groups and structured into modular programs. This organization will facilitate any future software enhancements and program maintenance. The goal of portability requires a variety of software tools. First, the selected operating system is UNIX (trademark of Bell Laboratories), commercially available through a number of vendors and currently supportable by most microcomputer and minicomputer systems. To minimize system dependencies, most of the applications software is written in ANSI Fortran 77. All assembly level and machine-dependent codes are isolated in program libraries and reduced to low-level primitives. The goal of attaining software portability is dependent upon creating device-independent code, the third goal. To achieve device independence, all calls to specific I/0 devices are isolated in libraries, and device-specific graphics calls within the applications molecules are eliminated. All applications programs contain the ACM-SIGGRAPH "Core" standard graphics calls. The goal of building a user-friendly system is attained through software development techniques that isolate the user from the operating system and guide the user through the system. Creating concise and easy-to-follow user documentation, coupled with providing on- and off-line training materials, should minimize both the time required to learn the use of the system and the effort required to utilize this powerful terrain analysis tool effectively.

DEMONSTRATION PREPARATION

BACKGROUND. In January 1985, the 1st Armored Division (1AD), was briefed on ETL projects at its headquarters in Ansbach, West Germany. The TAWS project was received with great interest, and 1AD expressed an interest in having the TAWS demonstrated at its facilities. In March 1985, 1AD formally requested a TAWS demonstration in the fall of 1985. The demonstration dates of 7 October – 2 November 1985 were coordinated during a return visit to 1AD in July 1985. The site of the demonstration, the room, and the electrical requirements were discussed and established during the coordination visit. Arrangements were also made to set up an account for emergency service and supplies. The TAWS/1AD demonstration schedule is shown in figure 5.

As part of the TAWS participation in the Corps of Engineers' AirLand Battlefield Environment (ALBE) program, the Condensed Army Mobility Model System (CAMMS) was installed on TAWS by personnel from the Waterways Experiment Station (WES). Installation began in April 1985 and was completed in July 1985.

HARDWARE. ETL had planned on having a demonstration support contract in place prior to this demonstration. Contracting difficulties made this impossible, and as a result, laboratory personnel had to arrange the packing and shipping of the equipment and set up a maintenance and repair account. Packing and crating of the equipment was arranged through the Humphreys

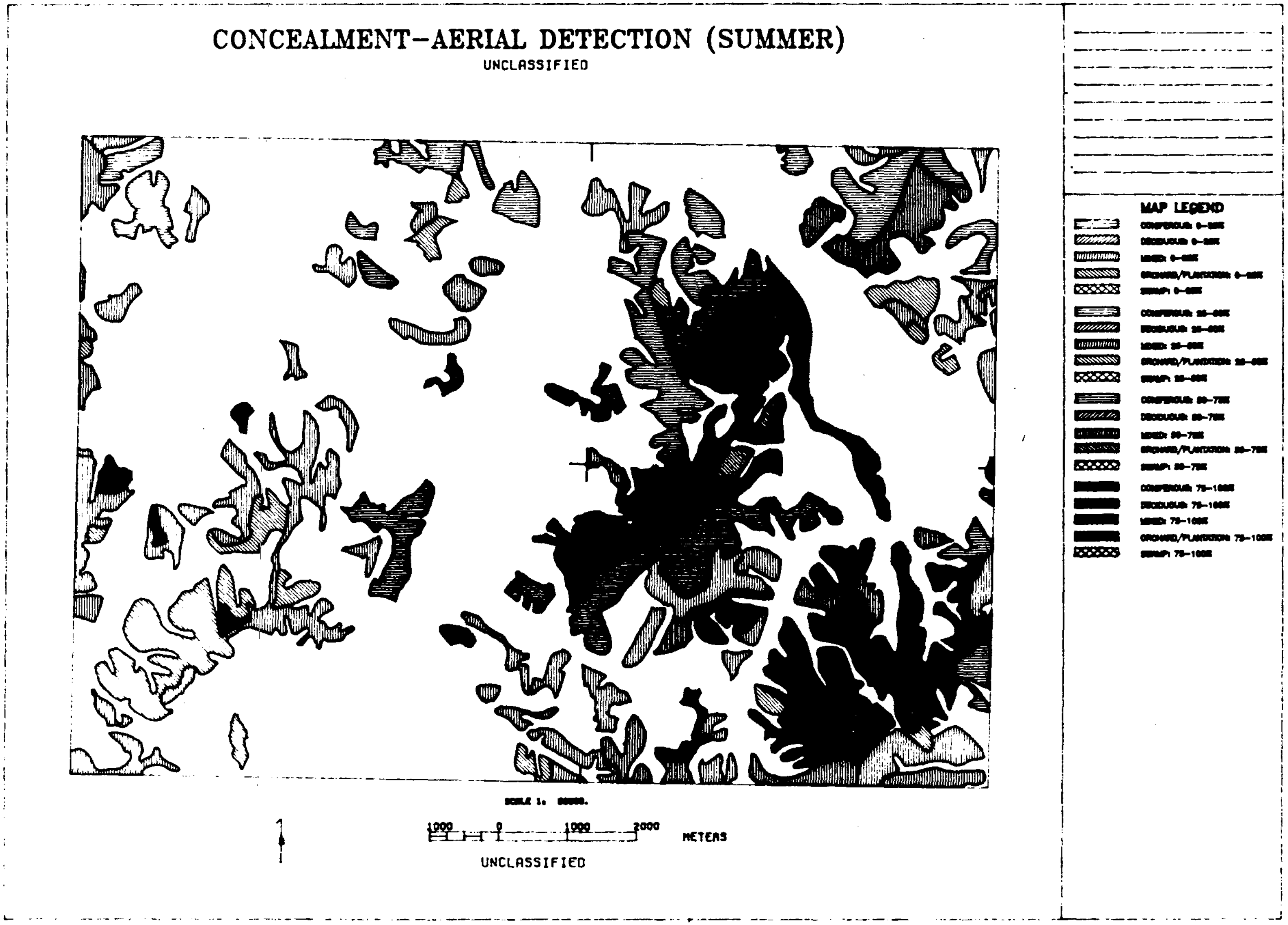

Figure 1. Concealment.

OBSERVER SITE INFORMATION

SITE ID	2-90	
MILITARY GRID LOCATION	32U	QA051236
TERRAIN ELEVATION	634.	METERS
OBSERVER ELEVATION	636.	METERS

PLOT INFORMATION

AZIMUTH OF VIEW	90	DEGREES
ANGLE OF DECLINATION	0	DEGREES
HORIZONTAL FIELD OF VIEW	60	DEGREES
RANGE LIMIT	20.	KILOMETERS
PLOT GRID INCREMENT	100	METERS
ELEVATION EXAGGERATION	5.	
RANGE LINE SPACING	1000.	METERS

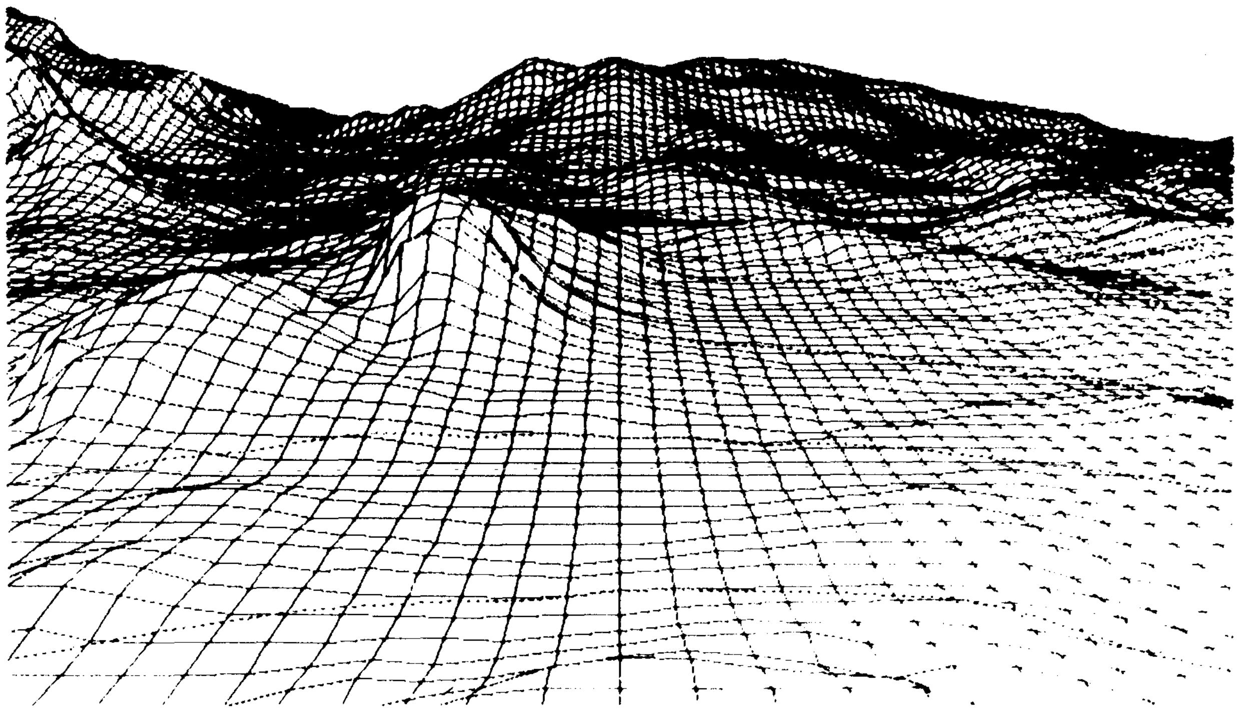

Figure 4. Perspective View.

OCTOBER 1985 / NOV

7	8	9	10	11	14	15	16	17	18	21	22	23	24	25	28	29	30	31	1	2
HARDWARE SET- UP			SYSTEM CHECK- OUT		1. DATA BASE CREATION		2. GENERAL TERRAIN ANALYSIS		3. INTER- VISIBIL- ITY ANALYSIS		BEES CAMMS	DEMONSTRATION and PRODUCT GENERATION						HARDWARE TEAR- DOWN and USER SURVEY		
					3		1		2											
					2		3		1											
					TRAINING															

Figure 5. TAWS/1AD Demonstration Schedule.

Engineer Center Support Activity (HECSA), and shipping via MAC flight was accomplished through the Fort Belvoir transportation office. Prior to the packing, technicians from Hewlett-Packard rewired and reconfigured the hardware to run on 220-volt, 50-cycle power. As a precautionary measure, a $5,000 support account was set up with the 649th Engineer Battalion (Topo) for maintenance and supplies.

Upon the equipment's arrival in Ansbach, arrangements were made to transport the system from Nuremberg to the demonstration location. All of the equipment arrived in good condition, and the system was assembled. Three pieces of equipment, the CPU and the two disk drives, tripped the circuit breaker immediately upon being switched on. Arrangements were made through the 649th S-4 office to have a Hewlett-Packard technician in West Germany come to the demonstration site and check the equipment. The technician determined that the rewiring by the U.S. Hewlett-Packard technicians was done incorrectly. Once he corrected the wiring, all three pieces of equipment ran correctly. The operating system and application software also checked out well, and there were no further technical or hardware problems during the remainder of the demonstration.

DATA BASE. The Defense Mapping Agency (DMA) was queried about the availability of digital and hardcopy terrain analysis data in the 1AD's area of interest. Digital Land Mass System (DLMS) data was available in the area. The Digital Terrain Elevation Data (DTED) subset of DLMS was usable with the TAWS system. All available DTED cells in the area of interest were obtained.

In hardcopy products, DMA had just completed five Tactical Terrain Analysis Data Bases (TTADB's) in the area of interest. An early release from DMA of these 1:50,000-scale products was arranged by the Terrain Analysis Center (TAC) at ETL. Two of the five TTADB's were selected for digitizing with the cooperation of 1AD. These two TTADB's, each consisting of slope, vegetation, soil, transportation, obstacles, and drainage factor overlays, were digitized by ETL personnel prior to the demonstration. Each TTADB set required 160–200 hours to digitize on the TAWS X–Y digitizing table.

TRAINING

The training phase of the demonstration began on 15 October 1985 and continued through 23 October 1985. A list of soldier-trainees, course instructors, and other demonstration participants is shown in table 1 and table 2. The training was organized around the software subsystems: data base development, general terrain analysis, intervisibility analysis, and environmental effects. In the next four sections the general training approach, course description, results, and comments for each software subsystem will be presented. With the exception of the Battlefield Environmental Effects Software (BEES) and a special session on CAMMS, the soldier-trainees were divided into groups of two. Each two-soldier unit was trained on a software subsystem for two days. The units then rotated to train on the next software subsystem. The BEES and CAMMS training was given to the entire training group and was followed by individual training during the remainder of the demonstration.

TABLE 1. List of Soldier-Trainees

Name	Organization
CW2 Lester Fitzgerald	518th Engineer Detachment, 1AD
SSG Susan Anderson	518th Engineer Detachment, 1AD
SGT Rose Stanislawczyk	518th Engineer Detachment, 1AD
SP4 Bradley Rogers	518th Engineer Detachment, 1AD
SSG Michael Edwards	526th Engineer Detachment, VII Corps
SP4 William Arena	526th Engineer Detachment, VII Corps

TABLE 2. List of ETL/WES Personnel

Name	Organization	Course/Duties
MAJ John Quick	ETL	Liaison
Mr. Laslo Greczy	ETL	Liaison
CPT Eric Musser	ETL	General Terrain Analysis
Ms. Robin Carroll	ETL	BEES
Mr. David Ference	ETL	Hardware
Mr. Michael Hardaway	ETL	Data Base Development
Ms. Joni Jarrett	ETL	Intervisibility Analysis
Mr. Robert Smith	WES	CAMMS
Mr. Richard Ahlvin	WES	CAMMS

DATA BASE DEVELOPMENT. This subsystem training focused on how the analyst can create, update, and revise a digital data base for an area of interest from an existing cartographic and/or photographic source. Also, training focused on preparing the digital data base for use in the general terrain analysis subsystem. Two Tactical Terrain Analysis Data Base (TTADB) mapsheets were digitized prior to this demonstration. It was planned for a third TTADB mapsheet to be digitized by the trainees during the product generation and additional data base creation phase of the training, but owing to time restrictions this was not done. Instead, a major road network overlay was added to the existing REFORGER data base. This overlay was initialized and started by the soldiers, but was not finished because of other responsibilities and time constraints.

Training Course. The training started with an Analytical Mapping System (AMS) overview and a general introduction to the three main menus that drive the AMS. After the overview and introduction, the soldiers received hands-on training, which allowed them the opportunity to test and exercise the various menus and options of AMS. After becoming familiar with AMS, the soldiers set up arbitrary projects for which they could create a digital data base. Once a project was set up by a particular soldier, he/she proceeded with digitizing the information selected by him/her to be put in the data base. When digitizing was completed, the soldier data based the information and exported it to the general terrain analysis subsystem.

Results and Comments. The general feeling of the soldiers for the data base development subsystem was one of acceptance and satisfaction. Once the soldiers comprehended the purpose of the subsystem and became acquainted with AMS, they were satisfied with the software and felt that it could be easily used as it is.

1. They felt comfortable digitizing , and liked the menu-driven software. All liked the idea of selecting an option instead of entering a command.

2. They would not want to be strictly a digitizer. The soldiers felt it would be all right to digitize some of the time, but not all of the time.

3. Some system options require more specificity, and there is confusion between use of the keyboard and use of the datatab cursor.

4. The system does not allow the user to digitize segments with a large number of points in it. After completing the segment with too many points, the system automatically deletes it.

5. In future demonstrations, more time needs to be spent digitizing useful PTADB or TTADB overlays rather than arbitrary training overlays.

6. The start-up menu should be reordered to be in a more logical sequence of events.

GENERAL TERRAIN ANALYSIS. This portion of the training focused on how the analyst can use the digital feature data bases that were created under the data base development subsystem. The two 1:50,000 mapsheets that were digitized prior to the demonstration were the primary data sources for both training and subsequent product generation.

Training Course. The training began with an introduction to four groups of the most commonly used commands, totaling approximately 30 commands. The groups are map information, map selection, map display, and analysis and statistics. After each group of commands was covered, the trainees had an opportunity to practice and test each one. Once all of the commands were understood, the training focused on how to take a commander's request for a terrain analysis product, do the necessary analysis, and plot the product to the desired scale. The soldiers in each cycle developed several products with different categories of information in each. A separate section of general terrain analysis training was devoted to mobility. The CAMMS software was taught in this section.

Results and Comments. The general feeling from all of the soldiers was that the software was powerful enough in most cases to do the type of work required, but it was not nearly "friendly" enough. A few soldiers quickly mastered the procedures and commands used. The others had considerable difficulty. Some of the most frequent difficulties encountered were the following;

1. There is too much "computerese" in software dialogue and error messages.

2. The method of issuing commands is inconsistent at times.

3. Certain data base retrieval procedures are very laborious and confusing.

4. Color and shading pattern assignment is inconsistent and duplicates effort, depending on whether the output is going to the screen or to the plotter.

5. Many commands that take considerable time to execute do not inform the user that something is going on. The user thinks that his terminal is not operating.

6. Mobility programs do not automatically add the multiple attributes (cross-country speeds, river-crossing conditions, etc.) to the base map. Instead, the user has to run a separate program to do this.

7. Some programs are inconsistent regarding whether they create a new active file or a new disk file.

Most of these inconsistencies are taken for granted by laboratory personnel who work with the system daily. However, it was very difficult for soldiers with limited or no computer experience to become comfortable with the software.

Another obstacle to a widespread demonstration of this subsystem's capabilities was the unavailability of feature data for the entire REFORGER area. Because only two 1:50,000 map-sheets were prepared in advance, the commander of the 518th was reluctant to solicit requests for feature analysis products. He did not want to frustrate commanders by telling them they could get products in one region but not in another. As it turned out, a substantial number of intervisibility products were requested for one of the two digitized mapsheets. Since the area covered by this mapsheet was of such great interest to 1AD commanders, more attention should probably have been focused on providing them with feature analysis products as well.

Based on the feedback from soldiers and on the perceptions of ETL researchers, the following recommendations are presented:

1. Redesign the software interface to offer a choice of a menu-driven session similar to the data base development software or a command-driven session as it is now. This would accommodate both the experienced and the inexperienced user.

2. Remove all inconsistencies, duplication, and "computerese" from the software. The computer/user dialogue should be in plain English.

3. Revise the data retrieval command to enable selection of specific ranges for a single characteristic or group of characteristics within a factor overlay. For example, if the user wants to retrieve all bridges over Class 60 from the transportation overlay, the current procedure requires manually evaluating every bridge on that overlay. This is a confusing and lengthy exercise that the computer should be doing.

INTERVISIBILITY ANALYSIS. Training in the intervisibility analysis subsystem of the TAWS software begins with an explanation of the DTED (Digital Terrain Elevation Data) data base. The discussion includes the structure of the DTED data into one-degree by one-degree cells and the spacing of the elevation values within each cell. The purpose is to provide the soldier with an understanding of the source of the elevation values accessed by the intervisibility models. Each model is then shown briefly and discussed to familiarize the soldier with the type of products available in this portion of the TAWS system. The intervisibility models include the Line-of-Sight (LOS) Terrain Profile, the Perspective View (PER), the Radial Terrain Masked Area (RTM), the Target Acquisition (TAM), the Multisite and Composite Multisite Target Acquisition (MTAM) and (CTAM), and the Shaded Color Elevation Contour Model (SCEC).

Training Course. The introduction to the processes that design and generate actual plots begins with an explanation of the structure of the DTED software menu. Aside from the main menu, there is the design phase menu, the product generation phase menu, and the utilities menu. With an understanding of the menus that separate the design phase from the product generation phase, the training proceeds to the individual intervisibility models. Each model is then introduced with a description of its purpose followed by a discussion of the various required input parameters. These input parameters are discussed in some detail because these are the values the user will enter to design and generate plots meeting their specific needs. A demonstration plot is then created using soldiers' suggested sample input values. This enables the soldiers to become familiar with moving between menus and data entry.

The next step is for the soldiers to design and generate their own plots. The soldiers encountered little difficulty in proceeding to this phase of the training. They all felt that the prompts within each of the models were understandable and easy to follow, enabling them to create their desired products.

Result and Comments. As the individual models were used in training and during actual product generation, recommendations were made as to how the models can be modified to be more understandable or to better meet certain needs. These recommendations are as follows:

1. Alter the format in which the military grid coordinates are entered. Initially determine whether the user has a 6-, 8-, or 10-digit mil grid coordinate and then prompt for the input of the indicated type. Currently, each model prompts for a 6-digit mil grid; then prompts can be eliminated if the entire mil grid is input at one time. This will also reduce confusion when the user has a mil grid other than the assumed 6-digit input coordinate.

2. Within the plot header information or elsewhere on the product area, indicate the security classification of the depicted plot (i.e. indicate whether secret, classified, or unclassified).

3. Additionally, within the plot header information, allow the user the option to indicate the map sheet number(s) and name(s) depicting the site coordinate(s) location.

4. Develop an additional model to display multiple Radial Terrain Masked Area Plots (RTM's) in relation to each other on the same plot, consistent with what is done in the Multisite Target Acquisition Model.

5. Modify the plot generation phase of the RTM model to save all input parameters after the site identification is entered. This adjustment would prove very beneficial in the production of multiple plots where all the input parameters to this phase, such as target altitude and mode of surveillance, remain the same. Saving these constant input values in a file for recall eliminates repetition, saves time, and reduces chances of mistakes in the generation of multiple plots. This modification could be included as an option after the site is entered to enable the user either to use these previously entered and saved values or to enter new values.

6. Combine a terrain profile capability within the RTM model. Enable the user to indicate a radial displayed in the plot using the graphics cursor or some other means and to receive information on the profile of the terrain along this radial. The returned information may be in the form of a profile plot depicted in an alternate window on the display screen.

7. Modify the perspective view model to enable the user to position the graphics cursor over a perspective view plot depicted on the terminal display screen and to request the military grid coordinates of that position.

8. Modify the Line-of-Sight Terrain Profile Model to display a type of bar scale indicating the vertical exaggeration of the terrain to give the user a better perspective of the terrain.

9. Modify the Shaded Color Elevation Contour Model to plot to a user-specified projection so that the finished product could be more accurately overlayed on the intended map.

10. Requirement data sheets identifying the necessary inputs for each of the models should be made available to the users. These sheets can be filled out in advance, giving the users an idea of the type of information required and enabling the products to be designed without last-minute questions concerning unknown input parameters.

11. During this demonstration several products were generated for a nearby area and were field checked, enabling the intended users to evaluate the results. All the products generated for this field test checked out well.

BATTLEFIELD ENVIRONMENTAL EFFECTS SOFTWARE. The Battlefield Environmental Effects Software (BEES) is a group of interactive programs developed to aid military personnel in characterizing the environment of the battlefield and its effects on equipment, personnel, and operations. The BEES programs can be divided into six major program groups: Climatology Data Bases, Operations, Almanac Functions, Mobility, Engineering, and Utility Functions. A subset of the current operating BEES programs is resident on the TAWS computer.

Overall, the opportunity to participate in the TAWS demonstration was beneficial. In addition to training members of the 518th Engineer Detachment (Terrain) and the 526th Engineer Detachment, two staff weather officers were briefed on the use and capability of the BEES. Both the training and the briefing are important because these programs will be fielded in spring 1986 as part of the MICROFIX-T effort.

Training Course. The training of the BEES programs was done for the most part on an individual basis. Each soldier was given a background on the development and uses of BEES and an explanation of each of the 14 programs. The soldiers then were given the opportunity to operate the BEES software. The military personnel encountered relatively few problems in its operation.

Results and Comments. Some of the soldiers' comments and suggestions which were received are as follows:

1. There should be a uniform method of requesting day/date information (i.e. consistently either day-month-year or month-day-year).

2. There should be an input request sheet for the programs, especially the engineering package and the cross-country mobility program, that the terrain personnel could fill out before running the program. This would enable them to obtain all the necessary information from the engineers, aviators, etc. before BEES was run.

3. Additional helicopters were requested for the density altitude/helicopter load capability program.

4. The menus that list equipment (i.e. helicopters or vehicles) should include either their common nicknames or at least generally what the item is.

5. There should be an option to print the results rather than always having the results printed out.

Note: Items 1, 2, 4, and 5 have already been incorporated in the MICROFIX BEES Version 2.1 to be fielded in spring 1986. These will be incorporated in the TAWS version of BEES.

SUMMARY

PRODUCT GENERATION. During the course of the demonstration, requests to produce products for numerous units were received. Each unit designated 20 or more plots to be generated. In many instances the information necessary to design and generate the plot was incomplete or sketchy, requiring further research by ETL. Before we were through, we organized and produced well over 600 DTED products, the majority being RTM plots. Over 100 BEES products were generated for the staff weather officers and others.

VISITORS. On 23 October 1985 a visitor's day was held. The TAWS capabilities were demonstrated by the ETL and WES representatives and the soldiers of the 518th Engineer Detachment, 1AD, and the 526th Engineer Detachment, VII Corps. The visitors who registered in the TAWS visitor book are shown in table 3. Fifty-two individuals attended the demonstration.

TABLE 3. Visitors

Name	Organization
LTC David Jennings	G-2, 1AD
MAJ Hartmann	Asst G-2, 1AD
CPT Kim	Asst G-2, 1AD
MAJ Frankenfield	Asst Div Engr, 1AD
CPT Gonzalez	Battalion Automated Battle Simulation,1AD
CPT Bruce Flaig	Staff Weather Off, 1AD
CPT Talbot	Staff Weather Off, 3ID
MAJ Larry Stancil	HQ USAREUR
Mr. Roger Ryan	HQ USAREUR
CPT Patricia Grider	HQ VII Corps, Asst Corps Engr
CW2 Willie McCrory	HQ VII Corps, Asst Corps Engr
Mr. Richard Duncan	DMALO, London
MAJ Johnson	Min of Def, UK
MAJ Wardrop	Min of Def, UK
MAJ Campbell	BAOR
MAJ Parices	1st British Corps
LTC Ronald Forkenbrock	Army Space Initiative Study, Fort Leavenworth
LTC David Linder	Army Space Initiative Study, Fort Leavenworth
CPT David Titus	Army Space Initiative Study, Fort Leavenworth
CPT Joe Kotch	526th Engr Det, VII Corps
CW2 J. W. Walters	526th Engr Det, VII Corps
SFC Small	526th Engr Det, VII Corps
CW2 Tatro	510th Engr Det, 3ID
SFC Ward	510th Engr Det, 3ID
SSG Wise	510th Engr Det, 3ID
CW2 Richard Butler	517th Engr Det, V Corps
SSG Calven Miller	517th Engr Det, V Corps

This list represents the principal visitors and agencies in attendance at the demonstration.

DEMONSTRATION FEEDBACK. At the end of the demonstration, an exit interview was held with each of the soldier-trainees to solicit final comments about the demonstrated technology, the TAWS system, and the automation needed by the terrain analyst. The TAWS Demonstration Feedback Form used during the interviews is in appendix A.

Although only one of the five soldier-trainees had some experience with ADP equipment, the majority of the soldier-trainees estimated that they could use TAWS routinely on-the-job after a 10- to 14-day learning period. They based this estimate on their belief that the training procedures and materials were effective and that the documentation was clear and concise.

In their comments on the TAWS system, the soldier-trainees indicated the technology was impressive and needed. In response to specific questions, they found the menu-based (user selection) portions of the TAWS system preferable to the command-based (user recall) portions. The majority agreed that more flexibility and more choices in menu selection were not needed, but suggested that the menu selections be reduced by having more functions performed automatically.

With regard to the automated terrain analysis demonstrated by TAWS, the soldier-trainees believed that this, or a more advanced, type of computer-assisted terrain analysis is needed by the terrain teams. They felt that the technology demonstrated would improve their production speed and would provide very useful products. Thus they commented that digital terrain data bases for their area of interest should be created by terrain teams. However, they found the current digitizing process tedious and time-consuming, and they commented that this was an area where improved techniques or automatic equipment was needed.

PRODUCT USER FEEDBACK. Comments on the TAWS-generated product were solicited in the aforementioned exit interviews and at a terrain conference after the REFORGER 86 exercise. The Product User Feedback Form used for the terrain conference is in appendix B.

As stated above, the soldier trainees found the TAWS products potentially very useful. In assigning priorities to TAWS capabilities and products, they gave equal value to each of the general areas taught in the demonstration.

The TAWS products generated for use during REFORGER 86 were intervisibility products. From this conference, 10 product user forms were returned to ETL. Nine respondees had used the TAWS products, and the tenth had just received the products and was in the process of using them. Seven respondees identified themselves as S-2's, two as S-3's, and one as an intelligence analysis/ computer operator. The most commonly used products were Radial Masked Area Plots (RMAP) and Line-of-Sight (LOS), and they were used primarily for communication and radar placement. One respondee used the perspective view plot for friendly and enemy views of the battlefield.

Three users had field checked the products, and three others intended to field check the products as time permitted. All three who field checked their products indicated that the products were reliable. Two users emphatically stated that the products saved time. Although four users responded that the products did not save them time, they qualified their responses by adding caveats to them. Three indicated the products did not save them time because the products were not for their area of interest, while the fourth response indicated that the product had not been field checked and reliability was unknown.

The product users indicated that the products they needed were river crossing, hydrology, cross-country movement, trafficability, and a weather-effect overlay. The recommended improvements listed by the users were seasonal changes, bilingual margin data lists, better resolution products, and margin data list changes so that a lay person can read and understand the data shown.

CONCLUSIONS

In addition to the previous results and comments obtained from the 1AD soldiers and the ETL/WES personnel during training, an exit interview was held with each soldier to solicit final comments about the technology demonstrated, TAWS system, and the automation needed by the terrain analyst. From a combination of the soldier's comments and the observation of the ETL/WES personnel, the following overall summary of conclusions is made. These conclusions will be considered for future TAWS demonstrations and for the DTSS development effort.

1. The user interface for the GIS on DTSS should be designed to accommodate the novice as well as the experienced analyst.

2. The DTSS GIS should provide the terrain analyst with a menu of predefined products for rapid generation as well as an interactive capability for product generation.

3. Currently the DTED manipulation software is a software package independent of the GIS. The two software packages should be integrated not only to enable execution from the same menu but also to enable products of one to be overlaid on products of the other.

4. All five TAWS terminals were in full use at all times because of concurrent briefings, training, and production activities. The Digital Topographic Support System (DTSS) should evaluate how many terminals they will need to field.

5. The level of experience and training for soldiers assigned to DTSS will vary from the novice to the highly experienced terrain analyst. There will also be occasions when rarely requested products are needed by the commander, and even the most experienced terrain analyst needs refresher training. The DTSS should have the capability of providing computer-aided training.

6. One of the difficulties that terrain analysts encountered with the TAWS products displayed on the graphics terminals was the lack of an easy means to check products quickly and to orient themselves to the real world. An analog or a digital map background capability on DTSS would aid the analyst in the product checkout.

7. The ink-pen plotter was the weak link in the time required to generate the products requested during the TAWS demonstation. A more rapid capability to produce products in full color is needed. Recommendations for consideration by DTSS include an ink-jet printer, a laser printer, and a digital interface to QRMP. Since DTSS replaces the DSS van of the TSS (reducing the reproduction capability available to the terrain teams), a link to the QRMP will be desirable for DTSS.

8. The soldiers participating in the TAWS demonstration and visitors to the demonstration site were interested in seeing more products derived from digital terrain feature data. The

quantity of digital terrain feature data for the demonstration was limited because of the manual digitizing process currently used to generate the digital terrain data bases. A rapid scanning digitizing capability would be beneficial to TAWS and to DTSS.

9. Because of the training demands, briefing demands, and product generation requests, future demonstrations require a minimum of five ETL representatives be available for garrison demonstrations. Because field exercises operate around the clock, more personnel will be required for the demonstrations.

10. The customers who requested products during the demonstration were not familiar with the input data required from them to accurately generate the product they desired. In many instances time was lost determining the exact information needed to generate the requested product. Thus, product request sheets should be prepared and distributed to the requestors so that all required data would be provided.

11. The backlighted digitizing table was useful for numerous applications not suited for an automatic scanning digitizer. This, if a scanning digitizer is added to TAWS or DTSS, the backlight digitizing capability should be retained in some useful form.

APPENDIX A. TAWS DEMONSTRATION FEEDBACK FORM

INSTRUCTIONS:

The following questionnaire is designed to provide ETL with feedback on the TAWS demonstrations. Your comments are most welcome and will assist us in demonstration planning. We want to ascertain that we are addressing your concerns.

Please do not put your name on the form. If you wish to be sent a copy of the demonstration feedback results, leave your name and address with one of the ETL personnel.

Answer all questions that apply to your experiences with TAWS. Write "N/A" (not applicable) to all questions that do not apply to your experiences with TAWS.

Thank you.

1. Your background.

Rank____________________ Major duties, responsibilities:__________

Do you use any automated terrain analysis equipment at your current job? Yes/No._____ If yes, please describe. ____________________

2. Your experiences with TAWS.

Circle the appropriate letters for all that apply. Received capabilities demonstration only (D), Received Formal Instructor Training (T), Conducted Hands on Use with minimal Supervision (H).

D T H (A) Data Base Development

- D T H 1. Job Initialization
- D T H 2. Map Attribute Schema Construction
- D T H 3. Digitization Functions
- D T H 4. Edit/Update Functions
- D T H 5. Mensuration Utilities
- D T H 6. Verification
- D T H 7. Export to General Terrain Analysis Component

D T H (B) Terrain Analysis

- D T H 1. Add Maps to a Project
- D T H 2. Project Maps
- D T H 3. Select Maps/Map Features
- D T H 4. Display Functions
- D T H 5. Data Analysis and Descriptive Statistics
- ~~D T H 6. Prepare Map Product/Legend/Plot Map~~
- D T H 7. Prepare Cross-Country Mobility Products (DMA, European, CAMMS—circle each that apply)
- D T H 8. Prepare River Crossing and Bridge Erection Products
- D T H 9. Other (Describe)

D T H (C) Intervisibility Analysis Products

- D T H 1. Line-of-Site
- D T H 2. Perspective (3-D) Views
- D T H 3. Radial Terrain Masked Plot (RTM)
- D T H 4. Target Acquisition Model (TAM)
- D T H 5. Multisite TAM/Composite TAM
- D T H 6. Contour Elevation Plot
- D T H 7. DTED Utilities Functions

D T H (D) Battlefield Environmental Effects Software (BEES)

D T H 1. Climatologies
D T H 2. Operations
D T H 3. Almanac Functions
D T H 4. Engineering
D T H 5. Utilities

Comments on any component of the system: (optional)______________________

____

____

____

____

3. TAWS Training.

I received ________ hours of training on the following components of TAWS: (Use letter and number designator from question #2). ______________

____

____

Please check the appropriate response:

The introductory slides were

_____too detailed
_____of adequate detail
_____not detailed enough

Comments (optional)____

____

____

The hands-on training sessions were

_____too detailed
_____of adequate detail
_____not detailed enough

Comments (optional)____

____

____

The organization of user's manuals and training materials were

_____adequate, fairly easy to follow
_____particularly concise and clear
_____vague and needed more clarification

Comments (optional)____

____

____

____

4. System Use.

Learning to use TAWS seems like it would take ________ days.
(fill in blank)

Comments (optional) ____

____

____

Assume you have dedicated whatever time is required to become proficient at using the system.

(True/False Questions)

The system looks like it would be easy to use. T / F
Why? ____

____

I would want more control over what the system does rather than being led through the system via a series of menus. T / F
Why? ____

____

I would want the system to perform more functions automatically (eg. fewer user choices). T / F
Why? ____

____

I would prefer the entire system be operated by entering commands rather than selecting options from menus. T / F
Why? ____

____

(Multiple Choice)

The TAWS System would

_______ a. speed up the time it takes to do my job presently.

_______ b. not change the time it takes to do my job presently.

_______ c. would slow the time it takes to do my job presently.

5. Product Usefulness.

Do you feel that the products produced by TAWS are useful and beneficial to your needs?____________If yes, How?__________________________
__________If no, Why not?____

____

Of the products produced by TAWS, list the ones that you believe were the most beneficial to your needs. (List in order of importance with the first item being the most beneficial).____

____

____

____

Of the products produced by TAWS, list the ones that you believe were the least beneficial to your needs. (List in order of least importance with the first item being the least beneficial).________________________________

____

____

____

What additional products that were not produced by TAWS do you have a need for?____

____

____

With the training provided, were the TAWS Products easy to generate?_____

From your standpoint, how could this process be improved?______________

____

____

6. Demonstration Follow-up.

Do you believe TAWS would allow you to perform your job faster and improve your overall job performance?__________Why?______________________________

____

____

Do you believe there is a need for TAWS by the Terrain Units?__________ Why?____

____

Do you believe any of the capabilities of the system are not needed?_____ __________If yes, which ones?____

____

Do you believe additional capabilities are needed on TAWS?______________ If yes, please list.____

____

As a user, would you feel comfortable in creating your own data base for a specific area of interest? Why?____

If it were possible, would you be interested in a return demonstration of TAWS (with enhanced capabilities)? _________ If no, why?____________________

If yes, what specific capabilities and products would you want to see?______

APPENDIX B. PRODUCT USER FEEDBACK FORM

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
(ETL)

TERRAIN ANALYST WORK STATION PROJECT
(TAWS)

INSTRUCTIONS:

The following questionaire is designed to provide ETL with feedback from the users of products generated from digital terrain data by the TAWS. Your comments are most welcome and will assist us in the development and design of products which will best meet the user's needs. We want to ascertain that we are addressing your concerns.

If you desire a copy of the After Action Report when it is published, please provide your name and address on the last page of this form.

Please answer all questions that apply to your experience with TAWS generated products. Write "N/A" (not applicable) to all questions that do not apply to your experience with TAWS products. If the space provided for answers is too small, please continue comments on the reverse side of the page.

Please keep your answers UNCLASSIFIED.

THANK YOU.

1. Your Background.
Rank______________________________
Major Duties, Responsibilities______________________________
____
____

2. TAWS Products

Did you use products generated by TAWS?
Yes_____
No _____
If no, please skip to section 3.

Check which TAWS product(s) you used. Please indicate how you used the product.

Masked Area Plot_____ Applications______________________________
____
____

Perspective View_____ Applications______________________________
____
____

Line-Of-Sight_____ Applications______________________________
____
____

Target Acquisition Model _____ Applications______________________________
____
____

Mutli-Site Target Acquisiton Model_____
Applications______________________________
____

Battlefield Environmental Effects Software (BEES)_____
Products used ?______________________________
____
Applications______________________________
____

Mobility Products_____ Applications______________________________
____
____

Other Products used Products______________________________
____
Applications______________________________
____
____

Did you field check any of the products?

Yes_____
No _____

Were the products reliable and accurate enough for your needs?

Yes_____
No _____
Unable to Assess_____

Were products useful and beneficial to your needs?

Yes_____
No _____
If yes or no, why and how?_______________________________________
____
____

How may the products be improved? (Mark products not used "N/A".)

Masked Area Plot____
____
____

Perspective View____
____
____

Line-Of-Sight____
____
____

Target Acquisition Model____
____
____

Multi-Site Target Acquisition Model______________________________
____
____

Battlefield Environmental Effects Software (BEES)______
____
____
____

Mobility Products____
____
____

Other Products used____
____
____

Did having these products save you time and/or labor?

Yes____ How much?____

____

No _____ Why?____

____

____

3. Products Needed

What terrain analysis products do you most often generate or need? (1 is the most frequent product, 2 the next most frequent, etc.)

1. ____

____

2. ____

____

3. ____

____

4. ____

____

5. ____

____

4. Other Comments

____

____

____

____

____

____

~~5. Address for After-Action Report~~

____

____

____