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The U.S. Army Corps of Engineers (USACE) has, historically, been the focal point within the Army for topographic surveying and mapping. The U.S. Army Engineer Topographic Laboratories (USAETL), a USACE research and development laboratory, has spearheaded research and development in the mapping sciences, developing automated mapping and surveying systems and supporting development of tactical system that process digital topographic data (DTD). USAETL has long been an active participant within the mapping community for fostering

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ARMY REQUIREMENTS FOR DIGITAL TOPOGRAPHIC DATA

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INTRODUCTION

The U.S. Army Corps of Engineers (USACE) has, historically, been the focal point within the Army for topographic surveying and mapping. The U.S. Army Engineer Topographic Laboratories (USAETL), a USACE research and development laboratory, has spearheaded research and development in the mapping sciences, developing automated mapping and surveying systems and supporting development of tactical systems that process digital topographic data (DTD). USAETL has long been an active participant within the mapping community for fostering scientific and technological advances in the production and use of DTD, often in concert with other Department of Defense (DOD) organizations, such as the Defense Mapping Agency (DMA).

The advances in the digital mapping world over the past 10 years have been so rapid that they have been collectively termed "the digital topographic revolution." This revolution has brought significant changes to the mapping world and also some special problems. For the Army, these problems surfaced in the early to mid-1980s as an increasing number of users began developing applications for DTD at a time when there were few available standard products that could meet individual user requirements. In this environment, developers saw little choice but to produce customized DTD and pursue independent strategies for software development.

Some system developers, dependent on their contractors for technical support, also relied on that support for the generation of what often proved to be expensive, nonstandard data bases for system development and testing. In addition to expending funds for their nonstandard test data set, some developers discovered only too late that a similar data set had already been produced for that test site by another developer. Other developers, not experienced in using DTD products in their applications, tended to overstate their requirements, typically in terms of product accuracy and resolution. DTD applications development also suffered through the lack of standards for products (i.e., structure and format, distribution media), algorithms and software. There was also a lack of commonality in the selection of hardware platforms and operating systems - even within primary mission areas.

These problems were eventually brought to the attention of the Army Vice Chief of Staff and, in 1985, he concluded that (1) the proliferation of nonstandard DTD was unchecked, (2) there was evidence of redundant contractor support, (3) DTD requirements were often overstated, (4) software and hardware standards were

lacking and (5) **there was no central point of contact within the Army to address these concerns.**

In 1986 the Concepts and Analysis Division (CAD), later renamed the Digital Concepts and Analysis Center (DCAC), was created within USAETL to serve as the Army's primary source of technical expertise for all military applications of DTD. DCAC's functions include (1) providing technical support to the Army Research, Development, Technology and Engineering (RDT&E) community, (2) analyzing, coordinating and technically endorsing Army requirements for DTD, to include processing requests for standard DMA products, (3) maintaining technical liaison with DOD, DA, DMA and private industry, (4) serving as a technical resource for combat developers and the analysis community, (5) conducting technical reviews of requirements documentation and doctrinal publications, (6) providing/evaluating prototype terrain data bases and (7) developing Army end-user mapping, charting and geodesy standards. Through these functions, DCAC can ensure the materiel developer and combat developer of reasonable database support, prevent the writing of overstated DTD requirements and eliminate redundant contractor support.

REQUIREMENTS ANALYSIS

Site Visits

Coordination. Combat developers and materiel developers alike have benefitted from DCAC's personalized approach to requirements analyses through site visits. Site visits provide the personal attention to the individual customer's DTD requirements, which has been by far the most effective means at our disposal for providing technical assistance. Proper advance coordination of the visit with appropriate points of contact on-site is necessary. DCAC encourages the on-site points of contact to disseminate information concerning the pending visit, to ensure that all interested persons have an opportunity to attend. The larger organizations, Training and Doctrine Command (TRADOC) schools and Army Materiel Command (AMC) activities, typically have many projects, programs and other efforts underway. Visits to these organizations require more coordination. Depending on the number of briefings and demonstrations that are scheduled, DCAC may send two or three team members to a larger activity as customer schedules often overlap, making it impractical for one person to service all of the customers. Site visits vary in length; typically, they last two or three days, with larger sites requiring an extended visit of up to one week.

Briefings. The briefings conducted by DCAC members during an on-site visit consist of several elements that are tailored to satisfy the customer's needs. For new or seldom visited customers, DCAC members are always prepared to present detailed briefings on DCAC's mission, technical services, DTD products, DTD applications and data request procedures. Some customers

need more frequent refresher briefings on DTD, particularly in cases where there is a higher rate of turnover in key managerial and technical staff. DCAC briefings stress the theme that "an educated user of DTD is our best customer."

Positive initial contact with an activity can lead to better communication with customers down the road. For example, DCAC staff visited the U.S. Army Communications-Electronics Command (CECOM) to brief personnel from the Center for Software Engineering and the Center for Command, Control, and Communications (C3) Systems. As a result, DCAC was able to open a dialogue with those user groups. Over time, DCAC has provided technical assistance to these centers regarding DTD product formats and media. DCAC has also processed several data requests received from these centers.

Site visits also provide the users with an opportunity to demonstrate their system applications to DCAC staff and show how the data are used. These experiences are valuable for DCAC in that the analysts are not just relying on document reviews or telephone conversations but are actually seeing the interaction between the system and the system operator. Observing how the data is input, processed and displayed provides better insight to help analyze current and future DTD requirements.

Site visits can yield contacts with users that were not originally identified when the trip was planned. While briefing a group at the Air Defense Artillery School, Fort Bliss, TX, DCAC staff were invited to attend two system demonstrations that were not on the agenda, one for the Portable All Source Analysis System WorkStation (PAWS) and the other one for the PATRIOT Command Post Automation System (PCPAS). These demonstrations provided DCAC staff with the opportunity to see how these systems were utilizing DTD.

Defining Requirements

Educating DTD Users. DCAC has learned in the requirements definition process of the lack of user understanding of DTD and how their operational needs might be addressed by DTD and related technology. Education of users has become an important part of the requirements definition process. An educated user is more able to articulate his true requirements. DCAC is in the continual process of upgrading our educational program. The program currently includes a variety of standard briefings on services provided to Army programs, DTD products and topographic applications.

DCAC also provides customized briefings tailored to user needs. Our education program also includes demonstration capabilities where standard DTD products are used to demonstrate real terrain analysis applications on both UNIX and MS-DOS environments. Examples of applications would include line of sight, intervisability analysis, helicopter landing zones,

bivouac sites, etc. These systems have been demonstrated at numerous locations within the continental United States and at other locations such as Hawaii and Korea.

In order to periodically distribute updates on topics of interest, USAETL produces and distributes a quarterly newsletter, "The Digital Data Digest," which is available free-of-charge to the topographic community. DCAC also holds Army-wide quarterly technical exchange meetings on various topics of interest. DCAC plans to produce educational video tapes on digital topographic products and applications for distribution to interested users.

Defining User Requirements. One of DCAC's roles is to assist the combat developer in writing DTD requirements statements for a new system. These requirements statements are written to support specific system applications that will need DTD as an input. As part of this role, DCAC regularly reviews and comments on system Program Management Documents (PMD), especially the Operational and Organizational Plan (O&O Plan) and the Required Operational Capability (ROC).

These technical reviews provide DCAC with the opportunity to analyze the system applications and determine if any of them require DTD. The cover letter accompanying a draft O&O Plan or ROC usually contains an announcement of a Joint Working Group (JWG) or Technical Working Group (TWG) meeting that will finalize the draft document. DCAC staff have participated in these technical forums to defend recommendations made to add or revise DTD requirements statements in the PMDs. It is essential for the developer that requirements for DTD are stated early in the system's development cycle. This will help to ensure that standard DTD products and requisite area coverage will be available for system development, testing and eventual fielding.

During the materiel development cycle, a system fielding plan is formulated. Requirements for DTD products are defined in terms of area coverage, based on where in the field the system will be deployed; it is often worldwide. Due to such large area requirements, users are faced with the dilemma that DMA cannot provide coverage which satisfies all users and, therefore, compromises must be made. To help ensure that area requirements are addressed, the Unified and Specified (U&S) Commands submit, biennially, prioritized OCONUS area requirements for MC&G products directly to DMA. Army CONUS area requirements are submitted to DMA by ODCSINT. DMA reviews and reprioritizes the requirements submitted by DOD agencies and each of the military departments, and develops production plans to reflect overall service concerns.

Overstated Requirements. At a 1990 Council of Colonels meeting a DCAC representative attempted to share a humorous anecdote about an Army Program Manager in Germany that could not illicit any responses from contractors on his Request for Proposals (RFP) for production of a comprehensive one-meter resolution terrain

analysis database. Unfortunately, that Program Manager was in the audience! With the majority of overstated requirements, users are not aware of the high costs of creating very high resolution databases. Although the technology may exist to produce them, the cost would be prohibitive. While a contractor may be able to supply a custom-built, high-resolution data set over a small test site, providing database generation and maintenance over an operational area would be nearly impossible. Realistically, Army program managers do not have funds available to support that kind of DTD production. Also, there are technological limitations on the ability of current computer platforms to store and analyze high fidelity databases.

Some commanders want their systems to utilize a database which shows every stick and stone on the battlefield. The question here is: "Can the system perform its stated mission without such a dataset?" The answer is usually "yes." All users must be made aware of the realities of DTD production and availability and need to seriously consider the choices that are available to them, both in the near-term and in the future.

Tracking Requirements

DCAC has used a variety of data collection tools such as questionnaires and surveys to collect requirements data, with varying degrees of success. When administered by mail, these items seem to have a negative effect on respondents, which has often lead to DCAC receiving incomplete returns or no response at all from the organization. Personal contact, either by site visit or by telephonic coordination, have been more effective in obtaining system information relevant to DTD requirements.

In order to more effectively manage system information and support user requirements, the Army Terrain Requirements Database (ATRDB) was developed as a tool to aid DCAC in tracking, coordinating and assisting Army DTD users. The ATRDB contains information such as system applications, fielding echelon, types of DTD required, area coverage, data formats, mission areas (air defense, fire support, etc.) and areas of operations. A fully relational database, the ATRDB provides the DCAC analyst with pertinent system-related information. The ATRDB is an efficient means for (1) identifying and assessing known or anticipated DTD requirements, (2) tracking system developments and inter-relationships and (3) generating system status reports. Operator queries are supported by PARADOX database management software (DBMS) and a user-friendly interface between the DBMS and the operator, developed by PAR Government Systems Corporation.

CUSTOMER SERVICE

Matching Products to Requirements

There are four fundamental issues that invariably surface when talking with customers about choosing DTD products to

support their applications, issues that must be addressed when analyzing requirements:

Product Resolution. For elevation data, such as Digital Terrain Elevation Data (DTED), a matrix of regularly spaced elevation post points, resolution is expressed in terms of the distance between those post points. DMA-produced DTED Level 1, for example, has a post spacing of 100 meters or 3 arc seconds and is a medium resolution product. In contrast, DTED Level 2 has a post spacing of 30 meters or 1 arc second and is a higher resolution product. For feature data, such as Interim Terrain Data (ITD), resolution is expressed in terms of the scale of the features represented in the product. Planning Interim Terrain Data (PITD) is produced at a scale of 1:250,000 and is a medium resolution (i.e., planning-level) product. In contrast, ITD is produced at a scale of 1:50,000 and is a higher resolution (i.e., tactical-level) product.

Product Accuracy. Product accuracy relates horizontal measurements, such as the distance between elevation posts, to a known standard reference of measure. How close an elevation post is to the location of the actual point on the ground is defined as the horizontal accuracy of that measurement. Similarly, the accuracy of the vertical measurement of an elevation post is dependent on how close that measurement is to the actual elevation of that point on the ground. Accuracy statements are usually provided in product specifications. For example, DMA gives accuracy objectives for DTED Level 1 in terms of absolute horizontal (50 meters at 90 percent circular error) and absolute vertical (+/- 30 meters at 90 percent linear error).

Product Content. Content, defined in the product specifications, is driven by the intended uses for the product. Users sometimes try to shoehorn unsuitable data sets into their applications. The results are often less than satisfactory. For years, some Army systems used DFAD as the feature data input. DFAD is a product originally designed to support U.S. Air Force requirements for simulating radar returns and is used in developing tactical decision aids (TDAs) and applications. At the time, DFAD was the only digital feature data product available from DMA. With the development of ITD, a tactical-level, digital terrain analysis product, and its subsequent release as a standard product, DCAC realized this went further toward meeting Army requirements. Educating customers on the differences between these products resulted in many systems switching from DFAD to the more useful, and more appropriate, ITD.

Product content is sometimes confused with data density. Density is tied to the level of generalization of a feature product, and is often a function of scale. For example, a DFAD data set produced from digitized 1:1,000,000 scale Operational Navigation Charts (ONCs) will have a lower feature density per

unit area than if it had been produced from digitized 1:250,000 scale Joint Operations Graphics (JOGs). The reasoning here is that ONCs contain less map features, each of which are very highly generalized, whereas JOGs contain more map features that are individually portrayed in greater detail.

Product Suitability. Many DMA products are routinely being used to support a wide range of applications. DCAC works with customers to ensure that the correct products are being used. In submitting requests for data, not all customers are familiar with DTD products and their intended uses. Should a customer request an unsuitable product to support line of sight analyses, such as World Vector Shoreline (WVS) data, DCAC will coordinate with the customer to identify the problem, recommend the appropriate DTD solution (in this case, DTED Level 1) for that application, and then revise the data request accordingly.

Use of Standard DMA Products

Tactical Products. The proliferation of nonstandard databases during the 1980s was due, at least in part, to the small number of standard digital products available from DMA. The lack of a standard tactical-level digital terrain analysis product led the Army, in 1984, to articulate its requirements to DMA for a 1:50,000 scale tactical terrain data (TTD) product and a 1:12,500 scale Special Terrain Data (STD) product. DMA has never been in a position to support an STD product, but plans to begin producing TTD by the late 1990s.

Customers needing a tactical product in the 1980s were often put in the position of producing -- at great expense -- small, customized data sets to support system development and testing. The danger in following that path manifests itself when the system is fielded and no data are available from DMA to support operational requirements, unless the developer is able to fund DMA to produce a unique product. For example, prior to 1989, DCAC processed data requests from customers that wanted to use nonstandard tactical-level data sets such as the Army Training Battlefield Simulation System (ARTBASS) data. As DMA produced only five ARTBASS data sets, DCAC approved the use of those data sets for only a few proof of concept efforts, and required that the developer sign a conditional release agreement. Since DMA began producing ITD in 1989, DCAC no longer recommends or approves the use of ARTBASS data sets by system developers.

User Considerations. In an ideal case the user should determine the functional requirements defined by his operational mission and then integrate the least costly standard databases which will meet those operational requirements. Furthermore, nonstandard products will not be supported by the Defense Mapping Agency. Sustained use of a nonstandard product will result in the user incurring costs for product maintenance and, possibly, additional production. If the current suite of existing DMA products does

not meet user requirements, DCAC can assist the user in defining a new product and work with DMA to reach an acceptable solution. This lengthy process requires close coordination and cooperation with DMA and the other DOD services on the development of new prototype products that address the evolving needs of the topographic community.

In some cases, combat developers have allowed contractors to build custom databases to support their perceived DTD requirements. This practice is not viewed as a serious concern for wargame models and situation scenarios. However, the consequences of such a decision would be critical for a tactical weapon system. A fielded system will get its DTD products from one source -- DMA. Although databases of higher resolution and greater detail are desirable, Army must use products from DMA's current inventory. Reliance on nonstandard data will diminish as the need to adhere to using standard products increases, as with data communications and exchange on the battlefield.

Special Technical Support

Army Tactical Command and Control System (ATCCS). DCAC is providing technical guidance to the Program Executive Officer for Army Command and Control Systems (PEO-CCS) on the implementation of DTD. PEO-CCS is responsible for overall management of the acquisition and fielding of the Army Tactical Command and Control Systems (ATCCS) and other assigned systems. ATCCS will be the Army's comprehensive command and control program composed of five major tactical systems. These systems will provide maneuver control, air defense, combat logistics support, coordination of fire support, distribute intelligence information and provide electronic warfare counter measures.

ATCCS Requirements. Each of the five major components of ATCCS will require 1) a user interface based on a digital map background, 2) a suite of terrain analysis capabilities based on digital terrain analysis data and 3) a three dimensional terrain visualization capability. In order to enhance interoperability, eliminate redundant development efforts and reduce overall costs, PEO-CCS is standardizing map background and terrain analysis capabilities across Army command and control (C^2) systems. PEO-CCS has designated USAETL's DCAC as the technical lead on this initiative.

Current USAETL support can be divided into DTD requirements analysis, functional requirements definition, review of current capabilities and development of a standard "CCS Topo Module". USAETL provided substantial input to the Combined Arms Center on the development of the "ATCCS Map Background and Terrain Analysis Requirements" document. This document has served as a baseline for more in-depth USAETL research on PEO-CCS user requirements. The result of the user requirement studies will help refine functional requirements.

Software Standards. To maximize reuse of government owned software, USAETL is conducting evaluations of candidate software. Numerous USAETL software packages and software forwarded by PEO-CCS system developers and users will be evaluated. The technically superior algorithms which address ATCCS requirements will then be integrated into the prototype "CCS Topo Module" and ported to the ATCCS hardware (Miltope-Hewlett Packard 9000 Series). The concept behind the "CCS Topo Module" is to get a product to the user in the near term, and eliminate the need for any redundant developmental efforts by the component systems. User feedback on the CCS Topo Module will be used to tailor the capability before final development in Ada.

CONCLUSION

DCAC's emphasis on requirements analysis has been its best contribution to the Army's DTD user community, especially to the combat and materiel developer. There simply is no substitute for this service. Yet, requirements analysis is sometimes very time consuming, has many complexities and is resource-dependent. DCAC's Requirements Branch is responsible for providing this service to the Army. Requirements Branch staff regularly review incoming PMDs, attend JWGs and TWGs, answer data queries, process data requests, conduct site visits, collect requirements data, manage the ATRDB and support ODCSINT on many assignments.

The Requirements Branch does not work in a vacuum, however; DCAC's other two branches, the Special Studies Branch and the Standards Branch support each other in carrying out the center's mission. The Special Studies Branch maintains close contact with DMA baseplant operations, conducts technical evaluations of DMA prototype products and investigates a wide range of technical issues. The Standards Branch is proactive in supporting DOD standards for DTD product formats, media and applications software. DCAC is continually broadening its DTD expertise base, both through gradual internal expansion and through technical points of contact within USAETL and at the other Army laboratories. DCAC will continue to provide the Army with the very best in customer service.