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DEFENSE MAPPING AGENCY AEROSPACE CENTER ST LOUIS AFS MO
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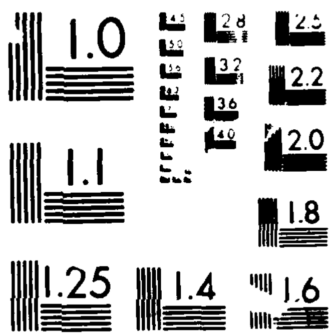

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The Defense Mapping Agency (DMA) pioneered in the development and production of Digital Landmass (DLMS) data to support various simulation systems for operational training. A variety of production techniques, procedures, software, and equipment have been developed by DMA since 1977. The Agency is currently responsible for the publication and distribution of product specifications for DLMS data and is also responsible for Multination agreements establishing standardized production and exchange of DLMS data. This presentation explores some of this production methodology. While not an historical treatment of the subject, production and methodology will be discussed in an evolutionary context. Finally, the presentation will explore some future considerations involving further evolution of the production methodology as well as comment on anticipated changes to the nature of DLMS data.

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THE DIGITAL LANDMASS SYSTEM

PRODUCTION OVERVIEW

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Introduction

The U.S. Defense Mapping Agency (DMA) pioneered in the development of Digital Landmass System (DLMS) data during the early 1970's. These efforts included a cooperative effort between DMA and the U.S. Air Force and various private U.S. contractors to develop data consistent with the requirements of available and planned weapons systems. Methodology employed during these early studies included the procurement of over 1000 radar scope photographs from both the Air Force F-111 and Navy A-6E. Determinations were made regarding which features on the ground were radar significant and how best to cartographically collect, store and display them. These studies resulted in the development of a DLMS Product Specification, which was initially published by DMA in 1974. The original purpose of DLMS data, which was to support radar simulation, has changed considerably in recent years. Today, DLMS data supports several visual and radar simulators as well as serving as a basis for further processing to permit other uses of the data.

The DMA is still responsible for publishing Product Specifications defining the data requirements and formats of DLMS data. Since 1974, these specifications have undergone periodic revision. Originally, DMA determined that the optimum production method was to collect terrain data separate from culture data. As a result, the 1986 publication of the specifications was separated into two volumes, one for terrain and one for culture. Also, because of the more universal use of the data, the DLMS designator has been dropped from the name in favor of Digital Terrain Elevation Data (DTED) for terrain data and Digital Feature Analysis Data (DFAD) for culture data. These DTED and DFAD Specifications now serve as the standard digital data base specification for the U.S. Department of Defense and also provide standardized production and format information for use by other producing nations.

Digital Feature Analysis Data-DFAD

The Digital Feature Analysis Data includes all cultural features, vegetation areas and lines of communication (streams, roads, power lines, etc.). Selection and portrayal of features is governed by minimum size criteria defined in the specifications. The DFAD data file contains a collection of feature shapes, locations, and attributes. The best way to understand the nature of this file is to review the production process used to generate it.

The initial DFAD production package contains aerial photography, a manuscript base and map control source for a manuscript area. The medium of exchange for DFAD is a full one-degree "cell". However, a unit of DFAD production is a manuscript. A one-degree cell may contain a maximum of 144 manuscripts or as few as one manuscript. The actual manuscript dimensions are usually determined by the scales of the aerial photography and the map control source. Maximum manuscript dimensions are also dependent on the digitizing equipment limitations. Production costs are usually minimized by selecting a manuscript of maximum size for the digitizing equipment used (that is, minimize the number of manuscripts in a one-degree cell). In areas of heavy density of features, manuscripts tend to be a smaller size and larger scale to allow for convenient portrayal of the features.

Features are selected for portrayal using photo interpretation of the aerial photography and the specification minimum sizes. Each feature is numbered (feature identification number) and a corresponding data file is built consisting of attributes for each numbered feature. The primary attributes considered are: feature identification number, length, width, height, orientation, surface material category (radar reflectivity), and feature type (point, line, area).

The aerial photography also provides the feature shape and relative location. It is necessary to transfer this shape and location from the aerial photography to the manuscript base. The important point is that we must ultimately draft an orthogonal shape and location of the feature on the manuscript base. Several methods can be employed to accomplish this and their details are beyond the scope of this paper.

The "feature analysis" phase of production is complete when all required features have been drawn on the manuscript and their attributes have been stored in an associated data file.

Next, we must convert the shape and location of each feature on the manuscript to a digital data file. This phase is called "digitizing" and it can be accomplished using several methods. One method is to use a digitizing table with a movable cursor and simply trace each feature. As the feature is traced, its shape and location are digitally recorded together with its identification number, as input by the operator. Another common method of digitizing is to scan the manuscript and record the shape and location of all features. The scan file is then edited for extraneous data and each feature is "tagged" by an operator with its feature identification number.

The "digitizing" phase is complete when the shape and location data file is complete. We now have two separate data files created: the shape/location file and the attribute file.

The "processing" phase of production involves merging these two files into the final DFAD file. This phase also includes minor adjustments to the shape/location file and, occasionally the attribute file, so that the manuscript matches its adjacent manuscripts. The final step in DFAD production involves the combining of all manuscripts within a one-degree cell into a single data set. This full one-degree cell of DFAD is ultimately stored in a central data base storage area which is called the Cartographic Data Base (CDB).

Digital Terrain Elevation Data-DTED

The Digital Terrain Elevation Data consists of a matrix of regularly spaced elevation values. The spacing of these elevations is approximately 100 meters in latitude and longitude, depending on the latitude of the one-degree cell. These elevation values reflect points on the ground and do not include the height of trees or structures. Those heights are taken into account in the DFAD production. The medium of exchange for DTED is a full one-degree "cell". A unit of production for DTED is also a one-degree cell.

Elevations can be collected using either existing maps or aerial photography. If the elevations are collected from existing maps, the contours are digitized either by tracing or scanning (as in DFAD digitizing) and that data is then processed into the required DTED matrix format. If the elevations are collected from aerial photographs, a profile is generated by scanning a stereophotographic model. This profile is then processed into the required DTED matrix format.

In DTED, the elevation matrix consists of 1201 by 1201 values (1,442,401 values in a one-degree cell). Because this matrix is oriented to true North, it is impractical to transform this data to other coordinate systems, such as UTM. If the matrix was transformed, the elevations would lose their accuracy and the data would be substantially degraded.

Transformed Data

The term "transformed data" is used to describe the combined DTED and DFAD data set which has been processed through simulator specific software prior to loading into the simulator. A separate transformation program is run for each visual and radar simulation. The purpose of the transformation software is to convert the "raw" DTED and DFAD into a form and format that is usable in the simulator. This would involve such things as assigning a radar reflectance or brightness code to individual features for radar simulation or assigning specific colors for feature surface materials for visual simulation. Currently DMA supports approximately seven different aircraft simulators.

Our original policy in support of simulators was that DMA would process the simulator specific software and distribute transformed data. This policy has recently changed. For all future simulator systems we now require the simulator contractor to build a system that will accept "raw" DTED and DFAD. Our experience has been that the simulator software requires some maintenance over time (particularly as mainframe operating systems change) and, because of the size and complexity of the transformation software, this maintenance has developed into a substantial effort.

Specifications

The current Product Specifications are divided into two distinct levels for data collection. The Specifications define a DTED Level 1, DFAD Level 1 and DFAD Level 2. In general, the Level 1 data is intended to portray that information which would be shown on a medium scale map and DMA has taken this to mean a scale of approximately 1:250,000. That is not to say that the compilation scale of Level 1 data must necessarily be 1:250,000. In general, the Level 2 data is intended to portray that information which would be shown on a large scale map and DMA has taken this to mean a scale of approximately 1:50,000. That is not to say that the compilation scale of Level 2 data must necessarily be 1:50,000. The primary distinction between levels of DFAD is the minimum feature size which is collected. In practice, this means that DFAD Level 2 contains a higher density of features and hence more detail can be portrayed.

At the present time, DFAD Level 2 is collected in small patches over areas of particular interest to the data user. Due to the high production costs, collection of DFAD Level 2 over large areas is impractical.

Data Applications

While, the original intent of DLMS data was to support radar simulators, the role of this data has changed substantially over the last ten years. Currently DMA Digital Data is used for Strategic and Tactical route planning for aircraft as well as Cruise Missiles; Army Terrain Analysis; visual and radar simulation for B-52, C-130, KC-135, A-6, F-111, F-16, and F-15; and navigation and guidance for Cruise Missiles and Pershing II. As more and more users become familiar with the data, new uses continue to be found. Moreover, the demands on the level of detail being sought by our users has also increased substantially. This it due to two primary reasons. First is the increased sophistication of the visual simulators which use the data. Secondly, as radar systems become more definitive, the accompanying data detail must also increase accordingly. We have experimented with several different versions of higher resolution DFAD as a substitute or replacement for current Level 2. Interestingly, the demands for increased levels of detail are concentrated in DFAD. Little interest has been shown to develop terrain models beyond what is already available in DTED Level 1. Our expectation is that the future will place greater demands on our ability to collect suitable data. More importantly, though, as the demands for higher levels of detail become defined, production costs increase substantially. The current challenge within DMA is to develop data sets which satisfy the users need for greater detail while also developing methods of data collection which are economically practical.

DTED Level 1 is now accepted as the standard medium resolution elevation data source for all US military activities and systems which require landform, slope, elevation, and terrain roughness information in digital format.

Internal Applications

DMA has developed methods to use both DTED and DFAD information as source material for map production. Efforts include converting portions of the DFAD file into map symbols which portray expected radar returns over built-up areas and converting DTED matrices to contour information. Follow-on activities will extract alignment and classification of features such as roads and streams for direct use in map production.

As a matter of interest, we are also investigating techniques to convert information gathered in the production of maps into usable Digital Data. These efforts are closely related to other efforts to automate various map production functions. The theory is that, if feature alignment and classification information exists in magnetic form, it can be used for both map production as well as digital data production, regardless of for which product the information was originally collected.

Summary

During the nearly fifteen years of DMA digital data production, substantial changes have taken place both in the methods of production as well as the nature of the final product. User requirements are evolving together with their systems which use digital data. DMA has continued to revise the DTED and DFAD specifications in order to better satisfy the user's requirements. Not only is the nature of digital data changing but also the geographic area of interest is expanding. Current DMA resources are unable to fully satisfy all requirements for all users. Thus, the near term production outlook is for various forms of compromise between the limited production resources of DMA and the increasing requirements of the US armed forces. DMA continues to experiment with various forms of data, attempting to develop cost effective products which better satisfy user requirements. DMA also continues to develop new and more cost effective production systems which will allow it to produce more data at a lesser cost. The DMA long term objective is to satisfy all validated requirements with cost effective products and DMA is financially committed for substantial capital investment to achieve this objective.

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