THE ASCENDANCY OF DIGITAL CARTOGRAPHY IN DMA'S FUTURE

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Introduction

The word ascendancy was selected for the title of this paper because it typifies the important role that digital technology is playing in the Defense Mapping Agency (DMA), especially to satisfy its growing family of digital data users. In addition to the Dictionary definition that comes quickly to mind, "State of moving or tending upward," which certainly typifies the current condition of DMA's digital capabilities, Webster also defines ascendancy as, "Controlling influences or governing power." This seems even a more apt description for us as we trend toward an all-digital production system in the foreseeable future. This is especially significant when we consider its modest beginning.

As I recall, we were hard pressed to even justify the beginning of the digital era. We had begun a modest digitizing effort at what was then DMAHTC's predecessor organization in the early 1960's. Using line following digitizers, we digitized elevation data from contour plates to permit automation of things such as relay tower locating and terrain-following flight testing. We began to attach digital recording devices to our analog photogrammetric equipment and to install analytical photogrammetric equipment that could output contours or elevation line drops. Digital map and chart compilation then grew out of these modest early beginnings. It was justified from an economy standpoint as the potential for elimination of negative engraving and a resultant 50% cost saving in the combined compilation and color separation production processes. It then took many years to get into productior with a manual digital system that finally began actual map and chart compilation within DMA in 1974. But now, only five years later, 59% of our resources are dedicated to digital and other products other than maps and charts, and this trend is expected to continue throughout the foreseeable future. We envisioned only an evolutionary change in some aspects of our production process as we took advantage of automated equipment. However, we soon found ourselves in a revolutionary posture as the digital data became not only a labor saving method of improving our production process, but also some of our most important products.

Since the advent of digitizing within DMA, the purposes for producing digital data have shifted considerably. The initial stimulus for the generation of digital data, i.e., automatic plotting and the consequent less expensive compilation and revision of maps and charts, has been overtaken by the need for the digital data itself as the product. The product applications that we are now directly supporting, or envision supporting with digital data, include such a diverse set of entities as cruise missiles, on-board aircraft computers, shipboard displays, terrain data for the commander in the field, and digital control for bombing from takeoff to automatic release using Global Positioning system guidance. Maps and charts will continue to be military products for a long time, and while we have introduced digital capabilities into the current map production process, their expanding role in the ultimate production of the digital elevation and culture data extends our product potentials significantly.

This paper will concentrate on the cartographic aspects of digital data as appropriate to this type of meeting. For more general coverage of the production trends within DMA, I highly recommend two papers written by DMA personnel in the recent past. In his opening address to the 1978 ASP-ACSM Annual Convention, our Director at that time, Lt. Gen. Martin [1] describes our increasing digital support to the military. At the Technology Exchange Week that took place in Panama in May of this year, Mr. Williams, [2] our Deputy Director for Systems and Techniques, addressed the production and data base aspects of a future all-digital DMA production system and related digital data bases. These two papers give a broad perspective of digital technology as it is increasingly being implemented in DMA. A further indicator of the increasing scope of DMA's digital activities can be better appreciated by noting DMA personnel's participation at this meeting. Our four participants are covering digital phases of DMA's cartographic future, digital data bases, digital terrain models and large system digital mapping.

In structuring this paper, I soon found myself with a main theme and at least three secondary themes. My primary message, as reflected in the paper's title, is that digital production and products are the wave of the future. However, in pursuing this theme, several additional messages emerged that may benefit those of you who are now in the process of implementing digital cartography. These additional themes that will be developed throughout the paper are:

Take advantage of the potential flexibility of digital data in developing a production system and digital or graphic products.

Comprehensive planning is a key element in the successful implementation of digital cartography.

Data standards are a primary consideration in the development of a cost-effective system, both for internal digital data use and external data exchange.

Current DMA Digital Capability

Three main kinds of instrumentation generate digital data within DMA: photogrammetric, manual line tracing and automatic raster scanning. The UNAMACE and the AS-11 are the workhorse analytical photogrammetric instruments producing digital elevation data. Bendix and Gradicon line-following digitizers form the bulk of our lineal digitizing capability. Our raster scanners include CBS Laboratory black/white scanner/plotters, a Hamilton-Standard, five color plus black, scanner, a SCI-TEX color scanner and Broomall black/white flatbed scanners. In addition, two of our major production processes are still manual, even though we have mounted R&D programs to automate them and bring them into the digital domain. Today, the generation of digital data under our Digital Landmass Simulation (DLMS) program is a manual production process that requires photointerpretation and digitizing of radar significant planimetric features, which are then combined with the photogrammetrically derived elevation data. Also, the source assessment and map/chart compilation/revision cartographic production stations are still completely graphic production operations. A small amount of production of maps and charts is being done digitally, but the preponderance of this production is still done in graphical form. As digital data applicable to map production begins to accumulate, the configuration of a compilation/revision station that permits the easy synthesis of graphical and digital data will be necessary.

Near Term Developments

We are heavily involved in both near and far term developments for continuing improvement in the digital arena. The significant near term areas that we are investigating represent extremely important technical improvements impacting on our continued successful implementation. These include:

Raster-lineal and lineal-raster conversion software. We are implementing a raster to lineal conversion capability to transform the output of the Broomall flatbed raster scanners for interactive lineal tagging and editing. We are also performing conversion software Research and Development (R&D) related to our other automatic scanners and plotters. We are also following other significant commercial and educational institution developments in this area, and expect efficient improvements in the near future.

Source assessment and compilation/revision work stations. DMA has in production a digital map/chart compilation procedure; however, the preponderance of our cartographic compilation and revision is still done by the age-old manual graphic methods. As we accumulate more digital data and want to use it in a cost-effective compilation system, it will be necessary to configure a work station that permits the combining of photographic, digital, and graphic materials and capabilities. Currently, DMA is funding R&D to configure this work station in two production areas, source assessment and compilation/revision. These are sequential production steps in which the source material to be used in each production step is evaluated and selected, followed by the actual compilation process in which graphic material is rectified for compilation and is then combined with the photographic and digital data as the product is compiled interactively. In addition to finding it a technical problem, we have also found that a considerable part of the difficulty is that a time-honored sequential manual production procedure does not necessarily remain in place after parts of it have become digital. It becomes difficult to configure an entirely new production procedure that eliminates some production steps, combines others that had not been sequential before, and brings together new groups of people that carry a diversity of skills that had not previously been combined. This leads to a marriage of R&D, techniques and production people that in themselves represent a diversity of backgrounds and outlook that need to be carefully integrated.

Manual and automatic feature extraction. Our current major effort in DMA is the selection and identification of cultural features in our Digital Landmass Simulation (DLMS) system. It is a manual, time consuming process. We are working to improve it in two stages. First, we are now contracting for a manual improved work station with the acronym of CAPI, Computer Assisted Photo Interpretation station. We are also heavily involved from an R&D standpoint in the pattern recognition or computer extraction of features. The capability has existed in R&D for several years for a computer to locate and identify preselected features from photography. However, this capability has not yet been successfully applied to mapping and charting type, feature extraction problems. Consequently, DMA has initiated or is following a number of R&D programs, ranging from basic research to production implementation, aimed at accelerating the extraction function.

Planimetry and elevation feature tagging. The advent of raster scanning is dictating a requirement to tag the features that are collectively scanned and digitized from a single manuscript. DMA's current tagging efforts are interactive in some cases but they are still entirely manual. The R&D programs in our supporting laboratories are looking initially at the automatic computer tagging of contours based on a minimal amount of labelling and the eventual automatic tagging of symbolized map and chart planimetric detail.

Interactive edit stations. The degree of success to be achieved in the use of digital capability is directly dependent on our ability to inspect it at key points during the production process in a cost effective manner. The best answer appears to be a series of interactive stations at which we can inspect and correct the detail and revise the data base accordingly. In response to this, DMA has installed, continues to install, and is researching a family of interactive edit stations.

Application of voice entry systems and optical character readers. These are typical of the peripheral equipment that we are developing and installing as additional refinements to our digitizing capability aimed at relieving the operators of the manual time consuming digitizing capability that marked the beginning of the digital era.

Far Term Developments

There are also a number of far term technical areas that are receiving attention. These include:

Mass storage systems. The key to success in a digital data production system is the development of a mass storage system which can make accessible the very large amounts of digital data that will accrue, along with a computer system that can successfully process and deliver the required data. DMA is investing heavily in these two areas, both from R&D and production aspects. The trend in storage in DMA is to a large mass store, but conversely, the trend in processing will be away from main frame and into distributive processing in various production areas. The big problem areas that are getting the bulk of our attention relative to mass store are the capability to update the data, rapid access, and an ability to purge the data to keep it as current as possible.

All-digital production system. With implementation based on feasibility and cost effectiveness, the availability and uses of digital data are permitting the conversion to an all-digital production system in the 1990 time frame. Questions remain in the conversion from our current film based production system concerning the speed of system development, frequency of human intervention and the equipment configuration involved in the display and manipulation of the data. In any event, the trend to digital is inexorable and the ease with which this total system can be implemented in an effective manner depends on the successful development of a responsive data base or data bases. Standardization of storage and exchange formats will be paramount so that the maximum number of products can be derived and a maximum number of data users can be satisfied. DMA is devoting a considerable amount of time and talent, and will continue to do so, to insure that a unified data base posture, interfacing with all interested parties, will receive top priority.

Data structure. A major part of our data base standards efforts is a look at new methods of data structuring and formatting in order to marry geometric and topological concepts. Our present geometric structures are satisfactory for data configured as it appears in a format usable in standard mapping and charting applications. However, it continues the concept of separating the detail of a typical map sheet into the components of its overlays of culture, vegetation, hydrography and elevations. We need to describe each square meter of the earth's surface as a complete entity with some means of expressing all of the interrelationships in the detail in a unified data base.

A significant trend in the recognition of the interrelationship of all of the components of terrain is indicated by the recent transfer of a component of responsibility from the Defense Intelligence Agency (DIA) to DMA. When DMA was formed and separated from DIA in 1972, the responsibility for terrain analysis and its related products was left with DIA. Now, however, by a Secretary of Defense memorandum dated 25 June 1979, the Terrain Analysis Program (TAP) has been transferred from the Intelligence Program to the Mapping, Charting and Geodesy Program. This adds responsibility to DMA for an entirely new series of products to support field operations.

Concluding Comments

The trends within DMA permit the following major assumptions concerning our future organization and capability:

Increased digital production culminating in an all-digital production system, based on feasibility and cost effectiveness.

A greater diversity in both graphical and digital products.

Centralized, unified and coordinated data bases for efficient storage, retrieval and purging, and also rapid data exchange with emphasis on standards.

Development of mass storage and massive computer capability, but with mini-computers assuming a more significant share of the processing load.

Communications technology that will permit world-wide dissemination of DMA data along with a direct printing capability to give instant printing of maps and charts virtually anywhere it is needed.

We are certainly in the midst of an exciting and challenging time with the implementation of digital technology. It is obvious that we can greatly benefit from sharing experiences. Beyond that, in the flexibility and exchangeability of digital data, we have a medium in which we can work with each other for real mutual benefit. We in DMA welcome this opportunity.

References

1. Martin, Lt. Gen. Abner B., A Military Manager Takes the Measure of Tomorrow. Photogrammetric Engineering and Remote Sensing, v. XLIV, No. 7, July 1978.

2. Williams, Owen W., Outlook on Future Mapping, Charting and Geodesy Systems. Inter American Geodetic Survey (IAGS) Technology Week, 13-18 May 1979, Panama City, Panama.