AD-A202 755

AIR WAR COLLEGE

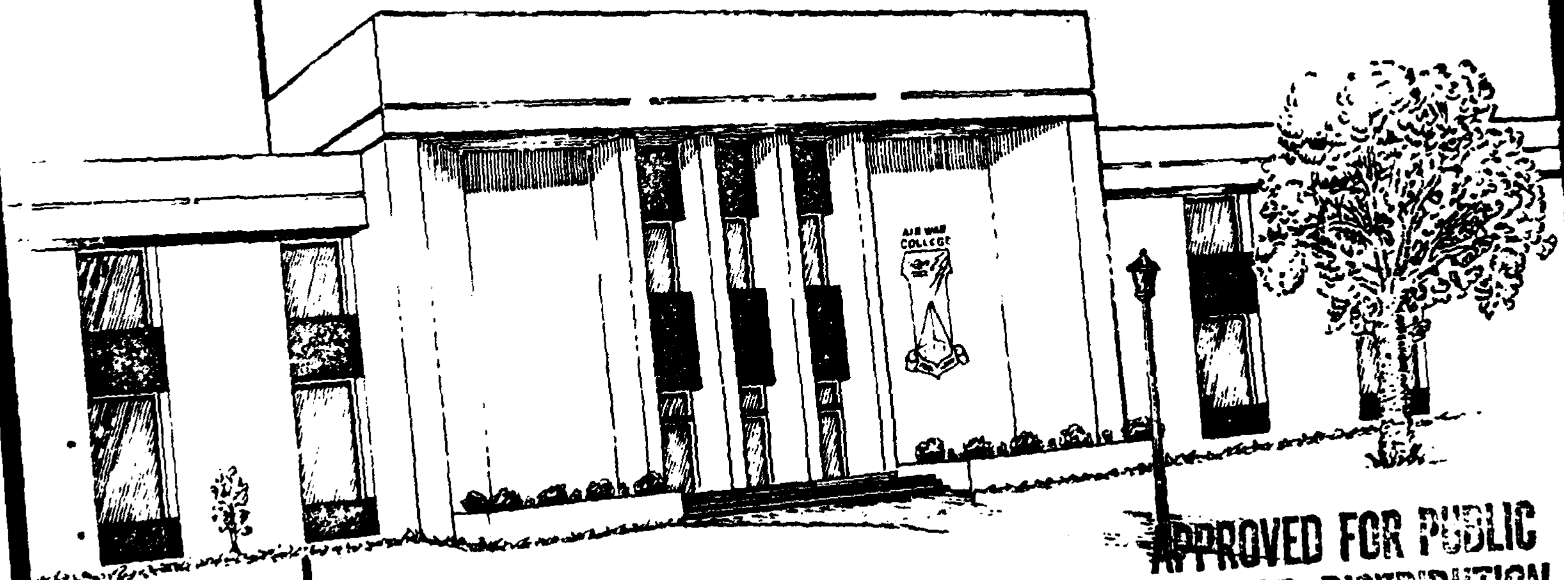
RESEARCH REPORT

THE LIFE CYCLE OF A DMA PRODUCT

DARRYL E. CRUMPTON

1988

DTIC
ELECTE
JAN 1 1 1989
S D
H



APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

AIR UNIVERSITY
UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

89 1 11 062

AIR WAR COLLEGE
AIR UNIVERSITY

THE LIFE CYCLE OF A DMA PRODUCT

by

Darryl E. Crumpton
Cartographer
DEFENSE MAPPING AGENCY

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Research Advisor: Colonel William Engle

MAXWELL AIR FORCE BASE, ALABAMA

May 1988

DISCLAIMER

This research report represents the views of the author and does not necessarily reflect the official position of the Air War College or the Department of the Air Force. In accordance with Air Force Regulation 110-8, it is not copyrighted, but is the property of the United States government.

Loan copies of this document may be obtained through the interlibrary loan desk of Air University Library, Maxwell Air Force Base, Alabama 35112-5564 (Telephone: [205] 293-7223 or AUTOVON 875-7223).

AIR WAR COLLEGE RESEARCH ABSTRACT

TITLE: The Life Cycle of a DMA Product

AUTHOR: Darryl E. Crumpton, Cartographer, DMA

The Defense Mapping Agency (DMA) is the DOD agency tasked to provide the Maps, Charts, and Geodetic (MC&G) products to the Armed Services. These products include the aeronautical products required for mission planning and inflight navigation, nautical products required for naval operations, topographic products required for land operations, and geodetic products required for precise targeting. DMA produces a wide variety of products to satisfy the many military operational requirements. These products range in format from lithographic (maps and charts), photographic (mosaics, Point Positional Data Bases, etc.) to Digital Data (machine readable data). Although these products differ in format and intended uses, they have the same life cycle. This paper will detail the current life cycle process in this one document. Heretofore, no single document exists which pulls together the multifaceted life cycle process. It is essential that the total process be clearly understood by the users and DMA personnel as well. Only through the life cycle process can the Major Commands be assured that the highest quality products are produced in the most efficient manner, in accordance with the users needs, in the priority areas they require them. This will become increasingly important as DMA begins the production of a distributive data base concept in the 1990's.

BIOGRAPHICAL SKETCH

Mr. Darryl E. Crumpton (B.A., Washburn University, Topeka, Kansas) has been employed as a cartographer with the Defense Mapping Agency (DMA) since March 1965. Nearly all of his 23 years of service have been accomplished at the St. Louis, Missouri based Aerospace Center (DMAAC). During his first 12 years, he was a research analyst and area specialist for Western USSR. As such, he specified compilation source materials for aeronautical chart production. He has served as program manager for the Aeronautical Charting program for DMAAC/PRN. In his last assignment, he was the Division Chief of the Terrain-Analysis I. This Division produced both Digital Feature Analysis Data (DFAD) and Digital Vertical Obstruction Data (DVOD). Mr. Crumpton is a graduate of Air War College, class of 1988.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

The Defense Mapping Agency (DMA) is the DOD agency tasked to provide the Maps, Charts, and Geodetic (MC&G) products to the Armed Services. These products include the aeronautical products required for inflight navigation, nautical products required for naval operations, topographic products required for land operations, and geodetic data required for precise targeting.

Historically, most of these products were lithographic maps and charts. Maps and charts still play an essential role in the planning and execution of military operations. Digital cartographic data is playing an increasingly important role. I define Digital Data as "machine readable data." The most common media for exchanging digital cartographic data is the computer magnetic tape, although cassettes are being used for certain low density files and optical discs are being used for very high density files.

DMA has been producing Digital Terrain Elevation Data (DTED) since 1972. DTED, along with Digital Feature Analysis Data (DFAD), were produced to support radar prediction for aircraft flight simulators. DTED and DFAD are still being used extensively for Weapon System Trainers (WST) for the A-6E, EA-6B, F-111, B-52, KC-135, C-130, F-15, F-16, and a higher resolution data will someday support the EF-111 and the B-1B. Although these data were produced for the WST's mentioned above, other applications were soon developed. DTED is extensively used by SAC for mission planning. DFAD has been used to produce correlation reference schemes for the Pershing II missile system. It is not my intent in this chapter to outline all the current applications for these digital data files, but rather I must make three points before I begin a discussion of this research paper. First, the sophisticated weapon systems of today and tomorrow have increasing reliance on digital MC&G products. Secondly, once produced, these digital products routinely have follow-on applications well beyond their original intended uses. Thirdly, DMA is currently creating digital data files which are specific product formatted. DMA will systematically cause these independent data files to be phased out in favor of a distributive digital data file from which the user will build their own products. This drastic change in philosophy will improve many production considerations for DMA, but has the potential to create operational/training difficiencies for the users.

During the research phase of this paper, I reviewed many DMA policy/procedural documents for the purpose of understanding what makes the current system work so well. It is important that the major DMA emphasis remains the satisfaction of the users requirements, while improving production efficiencies. In pulling together the interrelationships of the operational documents, it occurred to me that all DMA products have a "life cycle." They are conceived from a military operational/training need. They have infancy when their content and format are developed to meet the need. They have maturity during their useful life when they are constantly being improved to better meet the users needs. And finally, if they no longer fulfill a requirement, they are removed from the DMA Inventory of Required Products. This research paper will serve two purposes. First, it will become the only single document which describes this life cycle process (Chapters II through V). Secondly, it will document my perceived concept of the life cycle issue as it relates to the distributive data base design (Chapter VI).

CHAPTER II

THE REQUIREMENTS PROCESS

There are two parts to the requirements process: first is product definition, and second is area requirements. Product definition includes the format, accuracy requirements, content, density, and basically defines what the product will look like. Area requirements identifies where in the world a product is needed by a Unified or Specified Command.

Product Definition Process

In 1978, the Office of Secretary of Defense ordered that all new weapon systems be reviewed at inception for potential MC&G support requirements.[1] This was done to eliminate the possibility that a weapon system could be developed and deployed, only to find out later that the system was of no value until navigational data could be produced to support the system. After it is determined that a weapon system requires MC&G support, a DMA Office of Primary Responsibility (OPR) will be identified to support the development process. Example: A review of the Cruise Missile support requirements indicated a need for DMA support for mission planning and navigational data. A

---

[1]Deputy Secretary of Defense Memorandum, Subject: Implementation of August 1985 Program Decision Memorandum for Defense Mapping Agency (DMA) Programs, 6 June 1986.

similar review of the Silkworm Missile requirement indicated no DMA support requirement.

A DMA action officer from the OPR will be assigned to work with the weapon system engineering team.[2] This action officer will attend meetings on an "as requested" basis and keep close contact to ensure the MC&G requirements are not ignored. The action officer will be very knowledgeable of existing DMA products, production limitations based on availability, and utility of existing source materials. Source material may include digital data, photography, intelligence, or cartographic sources (both classified and collateral).

Because the DMA action officer is very knowledgeable of existing products, he will (whenever possible) try to satisfy MC&G requirements for new weapon systems with existing products. This is important for two reasons. The use of existing products will reduce costs for the weapon system and eliminate delays resulting from the pipeline production time for the new MC&G product.

Most of the time there may be some product in the DMA product line which will satisfy part of the weapon system's MC&G requirements, but other new products need to be developed to satisfy the entire MC&G requirement.

---

[2]DMA Fiscal Year 1988-92 Joint Manpower Program (Systems Center).

Again, the Cruise Missile is a good example of this. DMA was already producing DTED (which could be used for mission planning for the Cruise Missile), but additional data needed to be produced for the terrain correlation navigation system.[3]

The action officer is very knowledgeable of DMA's production capabilities. This knowledge includes the types of information obtainable, horizontal and vertical accuracies attainable, the currency and perishability of information, and a good estimate of the pipeline time required to produce a unit of data. The detailed information which DMA can provide is driven by available technology, attainable source materials, and DMA human and equipment constraints.

Prototype Development

Whenever it is determined that no suitable DMA product exists for a new weapon system, the DMA action officer will assist in the development of the required product. The primary driver will be system requirement. Secondary considerations will include the time and cost required to produce the required data. It may be necessary to modify the product requirements if it is impossible for DMA to produce sufficient quantities of data by a

---

[3]DMA Product Specifications for Terrain Contour Matching (TERCOM) Data Base, PS/4GE/100, PS/4GF/100, and PS/4GG/100, Second Edition, May 1985.

designated timeframe. DMA Systems Center (DMASC) will work closely with the systems engineers to derive the best product possible in the designated timeframes.[4]

The intended use of the product will dictate the type of data being generated. The project engineers define the nature of the MC&G support required (i.e., terrain, culture, radar, optical, etc., data). With close coordination, a data format/content is developed. The DMA action officer will document this in the form of a DMA Prototype Product Specification. After final coordination with the weapon system's Special Project Office (SPO) has been received, the DMA project officer tasks a DMA production element to develop production scenarios (which identify production options). Each production option will identify production equipment, personnel skills, total workhours, pipeline time, and total cost estimates for a unit's production. Senior DMA management will review the production options and select the most effective one (occasionally two).[5]

The production element will then develop detailed production procedures, which include quality control procedures, for the prototype product. After approval of

---

[4]DMA Fiscal Year 1988-92 Joint Manpower Program (Systems Center).

[5]DMA Manual 4070.10, DMA Configuration Management Program, 6 September 1984.

the production procedures is received, actual prototype production assignments are made.[6] Often the production assignments are made to two DMA Production Centers to permit the exchange of ideas and "lessons learned" during the difficult "first time" production process. Other benefits of dual center prototype production include verification of the quality of the specifications/ production procedures and some reassurance of the production costs/timeframes. This is an additional quality check DMA makes on most prototype product developments.

After the prototype products are completed, they are forwarded to the weapon system SPO for evaluation. This evaluation may be in the form of fly-offs, systems checks, comparisons with ground truth data, etc. Normally more than one prototype is required to develop the desired MC&G product.

Product Specification Process

After the prototype has been thoroughly tested and reviewed for content, it is necessary to develop a final Product Specification. This is accomplished by the Plans and Requirement Directorate (PR) of DMA. All DMA product specifications are prepared in accordance with the DMA Instruction for Preparation of Product Specifications.[7]

---

[6]DMA Manual 4070.10, DMA Configuration Management Program, 6 September 1984.

[7]DMA Instruction 8130.1, Subject: DMA Product Specifications, 9 April 1984.

This instruction dictates the format and basic content of the specification. The specific content is a reflection of the user/system requirement. Included in the product specifications are supersession notes. If this product replaces or substitutes for an existing DMA product, it must be so stated in the forward of the product specification. If the product is to be classified, there must be a statement as to who is the classification authority, and proper identification of the classification guide for this product must be made. If there are specific horizontal and vertical accuracy or currency requirements, they must be stated in the product definition portion of the introduction.

The major portion of any product specification describes the data format and content. I discuss two types of digital products in this paper: vertical elevation and feature data sets. Vertical elevation data are sets of ground elevations in a specified format. The elevation data may be exact values for specific geographic locations (as in the case of DTED).[8] Or, the elevation data may be average elevation values for a specified geographic area (as in TERCOM data).[9] The product specification will

---

[8]DMA Product Specifications for Digital Terrain Elevation Data (DTED), PS/1CD/200 and PS/1CF/200, Second Edition, April 1986.

[9]DMA Product Specifications for Terrain Contour Matching (TERCOM) Data Base, PS/4GE/100, PS/4GF/100, and PS/4GG/100, Second Edition, May 1985.

define the type of data collected, the collection interval, the units of measure, the reference datum on which the elevation data is to be collected, and finally describe the digital format. It is important to note that the product specification does not describe how the data is to be collected, on what equipment, or by what organization. This process will be covered in Chapter III.

Feature data describes the features on the earth's surface (buildings, towers, vegetation, hydrography, etc.). Again, the user/system requirements dictate data content and format.[10] The requirements for a visual system are understandably quite different from those of a radar system, since radar scenes are based on surface reflectivity. A metal building appears brighter than a wood building on a radar scope. It may be sufficient to position and size a barn, describe it as red, and identify the type construction (gabled or hipped roof, etc.) for a visual system. The visual system would then have enough information to position the proper sized/colored pictorial symbol at the identified location. That same barn would need additional descriptive information to support a radar system (such as, wall surface material, roof surface material, and orientation if it were a long enough building). This data would be necessary to provide the

---

[10]DMA Product Specifications for Digital Feature Analysis Data (DFAD) Level 1 and Level 2, PS/1CE/200 and PS/1CG/200, Second Edition, April 1986.

radar system enough information to determine the expected radar return for the various gain intensities and approach angles.

The product specifications for feature data then identifies the minimum collection criteria for each type feature being required by the user/system. Each type feature (roads, railroads, vegetation, etc.) being collected are identified. My example will be roads. In most areas of the world, because of the density of roads, it is impossible to delineate every road and have a usable product; so the product specification must define the selection criteria. Example: Delineate all dual lane roads, primary roads between major populated places, and only sufficient secondary roads to give a general idea of local secondary travel routes. (Secondary roads should not exceed one/square inch at compilation scale.) The above example identifies a possible selection criteria. The product specification would then go on to describe the feature "attributes" that must be collected about each feature. Again (to expand my road example), number of lanes, width, surface type, loadbearing capacity, etc., are attributes about the roads that need to be associated with the selected roads.

The product specification for feature data would go on to define the data format. In the case of DFAD, the largest aerial features are delineated first. After each delineation would follow the associated attribute data. The aerial features would be followed by linear, then finally point features. Most product specifications are quite complex, and much time and experience is required by compilation elements to become completely familiar with the selection criteria and feature attribute requirements. It should be remembered that the product specification identifies accuracy requirements, selection criteria, attribution requirements, and final format. In other words, it identifies WHAT is required but does not explain HOW it is accomplished.

A final draft of each product specification is furnished to all identified product users for review and coordination prior to printing and distribution. Any changes to the product specification made after distribution are accomplished in the Product Review Process, which is covered in Chapter V.

Area Requirements

After the Product Specification has been approved for distribution and prior to actual compilation of the data, DMA initiates an Area Requirements Survey.[11]

---

[11]DMA Instruction 8050.4, Subject: Submission and Validation of Area Requirements for Mapping, Charting, and Geodesy Standard Products and Services, 17 June 1987.

This survey basically determines, on a worldwide basis, what products are required and in what priority by Major Unified and Specified (U & S) Commands.

Annually, all Major Commands prepare requirements graphics which identify, by product, where and in what (Command) priority these DMA products are required.[12] HqDMA/PR coordinates and consolidates these requirements and prepares a publication called the DMA Assessment Graphic. This four volume set of graphics identifies the current production status of existing DMA products, programmed production, area product requirements, and relative production priorities. The Assessment Graphic is then used by the Major Commands to identify what products exist in their area of interest and the production status of nonexistent or inadequate products.[13] There are other monthly publications, such as the CHUM and Monthly Assessions List, which can be used to update the annually produced Assessment Graphic.[14]

In summary, the requirements process begins as soon as a need for a new MC&G product is identified. DMA

---

[12]DMA Instruction 8050.4, Subject: Submission and Validation of Area Requirements for Mapping, Charting, and Geodesy Standard Products and Services, 17 June 1987.

[13]DMA Instruction 8050.3, Area Requirements and Product Status (ARAPS) System, 23 June 1980.

[14]SDA SOP 8600.1, Chart Updating Manual, 18 December 1985.

personnel work closely with the system program managers to define the type of MC&G support required. Prototype products are generated/tested to determine the utility of these data. When the prototype is approved for system support, a DMA product specification is developed. This publication identifies what is to be collected and defines the final product format. After the final product specification is approved, the U & S Commands are surveyed to determine where the product is required and in what priority. After this has been completed, DMA is ready to begin the production process.

CHAPTER III

PRODUCTION PROCESS

The production process is a complicated cooperative effort which may take years to complete for a specific item. The production process begins after the requirements process has identified the required products, where they are required, and in what priority. For the purposes of this paper, I will address five phases of production: research, POM program, package preparation, data collection, and match/merge.

Research Phase

The primary purpose of the research phase is to determine the availability of source material to produce the desired product. This is essential because production cannot be initiated without the availability of adequate source materials. Before the Programs ard Productions Directorate (PP) puts specific products into production, a feasibility study is initiated to determine the adequacy of available source materials. As was indicated earlier, the product specifications identify horizontal and vertical accuracy and currency requirements for each product line. During the feasibility study phase, the research analyst will determine the availability of source materials to meet the stated accuracy and currency requirements.[1]

---

[1]DPI SOP 8530.3, VOD Feasibility and Planning Function, 30 June 1986.

To meet these requirements, there are basically three types of data: photographic, lithographic, and digital. DMA has access to many photographic data bases, both classified and unclassified. The classified holdings of DIA and CIA, along with the unclassified photography of USGS and the EROS data center, are available for DMA use. Certain of these photographic holdings can be used through photogrammetric methods to meet the horizontal and vertical accuracy requirements of the various products. These data bases identify area coverage, percentage cloud cover, data of coverage, and type of photographic coverage.

DMA has the most extensive lithographic map/chart library in the Free World. The current inventory of maps and charts is over two hundred fifty thousand. This worldwide coverage includes only those maps which have potential utilization in DMA product generation. These maps have been thoroughly evaluated, and information about each of them has been recorded in the Automated Map Information File (AMIF). Information such as area of coverage, date, producer, scale, horizontal and vertical accuracies, datum, and ellipsoid are recorded in the AMIF.[2]

DMA has been producing digital data since 1972. Two digital data bases have been maintained in the

---

[2]SDA SOP 8132.3, Automated Map Information File (AMIF), 12 October 1987.

Aerospace Center (DMAAC) located in St. Louis, Missouri, since that time. The first data base maintains the digital data itself, efficiently stores the data, and contains the necessary software for rapid retrieval of the digital data. The second data base contains information about the digital data (such as, area of coverage, collection date, horizontal and vertical accuracies, and currency date).[3]

Given these three data sets and the automated data bases containing information about their holdings, it should be apparent that the research phase is primarily querying these data bases for the proper parameters to permit the production of an acceptable final product (as defined by the product specification). Photographic and map/chart holdings routinely satisfy the horizontal and vertical accuracy requirements, while photographic source material is required to satisfy the currency requirements nearly 100 percent of the time. Currently digital data is used in the production of other digital data products and in the production of orthophotos.

Each assigned feasibility study results in an indication as to the adequacy of the existing source materials. If adequate source currently exists, the product is ready for production. If not, DMA initiates taskings to acquire the necessary sources to produce the

---

[3]DSM SOP 8422.1. CDB MACS Maintenance Procedures and Responsibilities, June 1987.

product. If tasking is successful, these products are generally ready for production the following fiscal year.

POM/Production Program

A number of factors enter into the decision as to which products are placed into production.[4] First, of course, is the availability of adequate source material to produce the product. This information is provided as a result of the research phase and is provided through the feasibility studies. The positive feasibility studies provide a number of production candidates. These candidates exist for all the various DMA products.

The next most important factor is the priority, as defined by the Major Commands. DMA is obligated to work on the highest priority production areas before proceeding to lesser priority production. For the most part, DMA selects the priority one products for which there is adequate source material as priority one production. Other factors come into play in choosing which priority two and three assignments will be placed into work.

Historically, DMA has been asked to produce a product where the lack of adequate source materials prevented the production of an adequate final product. In these cases, it was deemed important enough to have something, which may meet some of the military needs, as

[4]DMAAC PP SOP 7045.1, Subject: Preparation of DMAAC Program Objectives Memorandum (POM), 18 September 1987.

opposed to having nothing. Except for crisis support, instances of this nature are very rare.

Each product has production standards.[5] These standards vary for the various types of production. A revision production standard is, of course, less than that of a first time compilation. In a first time compilation, a complete source package must be built from scratch; and the analyst must compile every required feature. A revision assignment requires a source package containing only new materials acquired since the initial production; and the analyst is only required to revise/add those new or changed features.

DMA has a limited number of production personnel and equipment. The production of the priority one assignments will have fully utilized a certain percentage of these resources. Program managers utilize the remaining DMA resources to complete the most priority two and three products as possible, in the most cost effective and logical sequence. Contiguous block production is more cost effective than a "shot gun" selection of production assignments. The DMA Production Programmers (PP) ensure that production needs of all the Commands are accomplished. This is to ensure that one Command would not receive nearly all their production requirements, while other Commands received none of theirs.

---

[5]DMAAC Regulation 8501.1, DMAAC Integrated Status Reporting System (ISRS), 16 August 1982.

Because of the DMA shortfall of production capability relative to the military product requirements, the POM/production process is necessarily very complex. The primary factors of Command priority and source availability drive the DMA priority one production. The remaining production capability is scheduled to produce the most priority two and three products possible, giving equitable distribution between the Major Commands.

<u>Production Package Preparation</u>

Once the upcoming fiscal year production program is established, assignments are made to prepare the necessary source packages for these production assignments.* Specific organizational elements specialize in the preparation of these packages. These research analysts are thoroughly familiar with the production process and are responsible for the completeness and accuracy of the source packages. Photographic, cartographic, digital, textual, and intelligence information is included in the source package.

Photographic data bases are accessed to determine the necessary coverage for horizontal and vertical accurancy and currency requirements. These photographic sources are reproduced, indexed, and are a major component in most DMA production assignments.

---

*SDA SOP 8203.3, Preparation of Source Packages for Vertical Obstructions, 31 July 1981.

The AMIF is accessed, and selected maps and charts are accessed from the library (and reproduced, if necessary). Maps are excellent source material for control bases and feature classification. Thematic maps (such as, city plans, railroad, road, powerline, pipeline maps) are very helpful in classifying feature data. Each map included in the source package will have a stated intended utilization and associated evaluation data.

DMA digital data bases will be accessed, and all required digital data will be read to a tape which will become part of the source package. This digital data and its intended uses will become an important part of the source package and will have increasing importance as new computer driven compilation equipment becomes available.

Textual and intelligence information data bases will be accessed, and listings of available material will be provided in the source package. Only extractions from DIA's Automated Intelligence File is included in the source package. Items such as Atlas, Regional Area Studies, Population Census are maintained in the library for loan. These items cover large areas and are required by all production personnel, but generally not for long periods of time.

The source package is an important part of every production assignment. It contains/references all of the source material required to produce a given product. It contains the necessary photographic and cartographic material to meet the horizontal/vertical accuracy and currency requirements. Any necessary digital data is also included in the source package. The best available ancillary map, textual, or intelligence source is either included or referenced, along with an indication as to how the source may be used to determine feature attributes.

Data Collection

Much analysis and preparation goes into the product design and production selection process prior to the actual data collection. A weapon system was conceived which had an MC&G support requirement. DMA worked with the system designers and developed prototype products. A final product specification was approved which identified the data content and format. The Commands identified their area requirements and priorities. Feasibility studies were conducted to determine the availability of adequate source material. Production programs were developed to produce the prioritized production schedule. Source packages were prepared for subsequent product production.

True, much work has been accomplished; but much more remains. Remember, the product specification identified WHAT should be collected, but not HOW. Each production area has unique production problems and, therefore, must develop the best, most cost effective, production solution. One production area may have equipment constraints, so that a piece of production equipment is dedicated to only one person per shift. While another area may be constrained by computer turnaround. In the first case, it is necessary to assign one person one job to be completed from start to finish in whatever time is scheduled. In the second case, one individual may require several jobs to keep busy while waiting for computer turnaround.

Production flows are developed to determine the necessary production steps to produce a given product.[7] These production flows begin at Day 1 and terminate the day the product is ready for release (R4R).

A simple production flow follows:

Day 1	Retrieve/review contents of source package
Day 2	Orient stereo model
Day 2-120*	Compile DFAD Level I Manuscript
* Day 13 Day 60 Day 120	Perform 10 percent inprocess QC
Day 121-128	Match/Merge to Existing DFAD
Day 129-135	Perform 100 percent QC
Day 136	Release to Data Base

---

[7]DMA Manual 4070.10, DMA Configuration Management Program, 6 September 1984.

This is a simple example, because it basically involves one analyst and a supervisor and has no overlapping or simultaneous production efforts. It is not my intent here to expound on the complexity of the effort, but rather to indicate its necessity and the utility of the production flow.

The purpose of the production flow is manyfold. It documents the production process and identifies the need for production procedures, potential "bottlenecks," equipment and personnel requirements, and quality control checkpoints. Production procedures are generated for each production phase.[8] On Day 2, an analyst may need to establish a photogrammetric model, and then begin data collection. A separate production procedure is prepared for these two independent production phases. The production procedures instruct the analyst how to establish a stereo model. A separate production procedure instructs the analyst how to perform DFAD data collection. Each independent production action identified in the production flow requires a production procedure.

Analyst training is very important to the production of quality DMA products. Given that each phase of production has a production procedure, it may become apparent why it often takes six months to train an analyst

---

[8]DMA Manual 8130.2, DMA Production Documentation Manual, June 1987.

on how to compile a given product. The analyst must first become familiar with WHAT data is to be collected (Product Specification), then learn HOW to collect the required data (Production Instructions).

Another important part of the production phase is performance management.[9] All DMA digital products are formatted into one degree squares of data called cells. This facilitates the user, but not necessarily the producer of the digital data. Rarely, if ever, does the photographic source conform to that format. This makes it necessary to use several photographic models to cover the compilation area. It may be necessary with some photographic sources to use up to fifty separate models to compile one cell. It is even necessary to use photography from different sorties.

Nearly all DMA digital data production is assigned for completion within a fiscal year. In the case of DFAD production, it takes approximately three months to compile 2,000 features. A cell with more than 6,000 features cannot be completed by one analyst during the fiscal year, so it must be divided into sub cells, called task areas. The process of scheduling work, establishing task areas, and merging the task areas into cells, are all important parts of production management. It is the job of the

---

[9]DMA Manual 1434.3, DMA Performance Management System (PMS) Manual, November 1986.

production manager to ensure that the fiscal year production assignments are distributed in the most efficient manner and that the final product is of the highest quality achievable.[10]

The production manager uses the production standards to estimate scheduled completion dates.[11] Production standards reflect the average work hours required to complete a specific compilation function. These average standards frequently have to be modified to reflect real world conditions. Conditions such as poor quality source material may increase the production standard, while large water areas in the task area may decrease the standard.

The production analyst's performance is based on his/her accomplishments relative to these production standards.[12] There are performance standards for quantity and quality. The quantity standard identifies the number of features/elevations values an analyst must compile per hour to achieve a satisfactory rating. An analyst who exceeds this average rate will receive a highly successful or outstanding rating for this element,

---

[10]DMA Manual 1434.3, DMA Performance Management System (PMS) Manual, November 1986.

[11]DMAAC Regulation 8501.1, DMAAC Integrated Status Reporting System (ISRS), 16 August 1982.

[12]DMA Manual 1434.3, DMA Performance Management System (PMS) Manual, November 1986.

depending on the percentage of excess. The quality standard identifies the quality criteria for a satisfactory, highly successful, outstanding, minimally successful, or unsuccessful rating.

An analyst who does not meet the standards for these elements will receive a minimally successful or unsuccessful rating. Anyone receiving one of these ratings is subject to additional training and is placed on probation. If, at the end of the probation period, the analyst has not met the standard for successful performance, he/she is subject to removal from government service. These tough standards and measures of performance are essential elements in ensuring high performance and quality digital data production.

Merge/Match

As mentioned before, DMA produces digital data in one degree square cells, but may need several photographic models to complete the task area. The user/system requires a contiguous data base in which model/task areas are undetectable. DMA is committed to this difficult task. The final stage of digital data production is the merge/match function, which ensures the production of a contiguous data base.[13]

---

[13]DMA Product Specifications for Digital Terrain Elevation Data (DTED), PS/1CD/200 and PS/1CF/200, Second Edition, April 1986.

DMA Product Specifications for Digital Feature Analysis Data (DFAD) Level 1 and Level 2, PS/1CE/200 and PS/1CG/200, Second Edition, April 1986.

Two computer checks and "smoothing" algorithms are run on every completed digital data cell prior to release to the Cartographic Data Base (CDB). First, a cell merge is accomplished to ensure that any model-to-model discrepancies are resolved. This makes the cell internally contiguous. The second algorithm matches the cell to all previously completed adjacent cells resident in the CDB. It should be noted that the cells in the data base are not changed, but rather the new cell entering the CDB is altered as necessary to match to the existing data. This completes the production phase. The cell is now ready to be released to the data base and is available to the user/system.

CHAPTER IV

DATA BASE MANAGEMENT

As more and more digital data are being produced, the importance of an efficient data base management system increases. Data base management is much more than a library of digital data tapes. Data in the volumes that DMA has already produced would fill a warehouse if not efficiently stored. As volume increased, it would become increasingly more difficult to retrieve data if an efficient data base management system did not exist. The important data base management functions I will address in this chapter include storage, protection, retrieval, and distribution.

Storage

The DMA digital data base management system is called the Cartographic Data Base (CDB).[1] As indicated previously in Chapter III, digital data is released from the production area to the CDB in one degree square cells. These data cells are released on magnetic tapes and/or discs. The tapes generally include only one cell of digital data, while the disc contains many cells. The released cells are distributed to the CDB as completed,

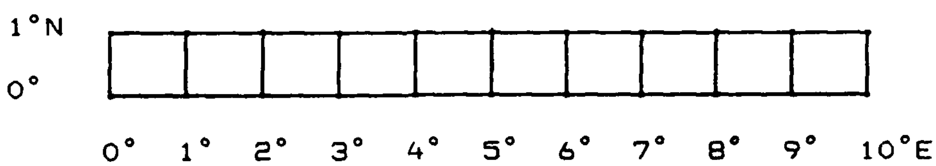
---

[1]DSM SOP 8422.1, CDB MACS Maintenance Procedures and Responsibilities, June 1987.

and are not always adjacent cells or contiguous blocks of data. Each tape/disc identifies the exact location on the magnetic media of each released cell. Because of the diverse release media and low density of data on each tape/disc, it is obvious that the released media are not suitable media for an efficient data base storage.

One cell of DFAD data occupies less than 1/25 of a 2,500 foot, 16 BPI magnetic tape. A cell of DTED is contained on less than 1/10 of the same magnetic tape. It is, therefore, possible to store multiple cells of digital data on each magnetic type in the CDB. The CDB efficiently stores digital data by data types in one degree latitude bands. The CDB is structured to store 10 cells of DTED data and 20 cells of DFAD on each data base tape.

Example:



The above example illustrates how the CDB is structured to store the 10 cells of DTED data from 0° to 1°N and 0° to 10° E. The world is divided into 1° x 10° blocks, and the CDB management system puts the completed digital data onto the appropriate magnetic tape for efficient storage. The system for DFAD data is similar; but since the data is less dense, 20 cells can be efficiently stored per magnetic tape.[2]

The structured storage of digital data cuts down on the number of tapes required to store the completed data, the size of the storage area, and the complexity of the retrieval system.

Physical Protection

The safeguarding of the digital data tapes is a very important function of the data base management system.[3] A single cell of DTED or DFAD costs an average of $7,500 to produce. The loss of this data would require complete recompilation. The loss of a CDB tape full of DTED or DFAD would cost from $75,000 to $150,000 to replace. The importance of data protection is very obvious.

There are two primary physical protection measures provided the digital data files in the CDB. First is the requirement for duplicate copy protection. The management system maintains two copies of every CDB tape. These tapes are given unique numbers and stored in different locations within the data base manager facility. This procedure protects against the accidental destruction of data. The second protection is an off-site storage of every CDB tape.

---

[2]DSM SOP 8422.1, CDB MACS Maintenance Procedures and Responsibilities, June 1987.

[3]ibid.

The physical protection of a second copy of all CDB tapes located five miles from DMAAC's physical site protects the CDB holdings from a catastrophic event (such as fire).

Within the tape library itself, there are additional protective measures which guard against the accidental destruction of these digital data. Each CDB tape has a unique bright green tape ring. This ring alerts the operator that the tape is a valued CDB asset and must be handled accordingly. The tape vaults have their own controlled environment. This environment maintains an optimum temperature/humidity to ± two percent. This environment is also a static-free environment.

The magnetic tape storage media is relatively stable. Rarely, if ever, is data lost or altered during storage for periods of six months or less. Due to the physical limitations of the storage media, data stored unused for long periods of time can loose bits of information. In the case of this digital data, this would be a catastrophic event. To counter this likelihood, every CDB tape is read once every six months. This exercise has proven beneficial in that a tape can retain error-free data for years.

<u>Retrieval/Distribution</u>

Only CDB personnel are permitted to handle the actual digital data tapes, but any DMA employee with proper access can retrieve a copy of the tape for use in his/her production activity. A batch run process is used to accomplish this. The retrieval run is submitted to the central site by the requesting individual. (Actually, this run can be processed through remote terminals as well, but the same process applies.) The computer operators stage the runs. As each run approaches execution, a cue goes to the vault for the specific CDB tape required. The CDB tape is mounted on an available tape drive. The required data is duped/tested, then made ready for release to the DMA requestor.

Data must also be retrieved for release outside of DMA. This activity is accomplished by data base management personnel. The activity is exactly the same as identified above; however, additional QC is performed before the tapes are actually released. Every cell of digital data is "viewed" (yes, viewed) on the Image Manipulation System (IMS).[4] This system produces visual schemes of the terrain/culture data, which is compared with a map of the requested area to ensure the proper area was retrieved. Internal algorithms check the data for completeness and compliance to specifications. After the QC checks are performed, the data is released to the validated external DMA user. Currently, this data is mailed to the

---

[4]DPM SOP 8421.5, Image Manipulation System (IMS) Procedures, February 1983.

requestor. In the future, data links will make it possible for near real time delivery of this data.

The Data Base Management System performs an important role in the life of a DMA digital data product. It efficiently stores the data, protects the data from accidental/catastrophic destruction, and provides for the retrieval of the data for internal and external DMA use.

CHAPTER V

PRODUCT REVIEW PROCESS

The product review is the process through which DMA receives feedback from the users. The purpose of the review is to determine the utility of the products and identify areas of potential improvement. There are two basic components of product review: user comments and the annual survey.[1]

User Comments

For years, users have reported errors and suggested improvements in DMA products through the User's Comment program. Every map/chart produced by DMA contains a note in the legend requesting users to report errors and suggest improvements. These comments are forwarded to the Quality Assurance Directorate (QA) within the appropriate production center. Every comment is investigated for correctness. All validated errors are reported to the user community through monthly publications, such as the Chart Updating Manual (CHUM) and Notice to Mariners (NOTOMS). Everyone submitting a user's comment will receive a reply which spells out the specific corrective action taken to resolve the errors noted.[2]

---

[1]DMA Instruction 8052.4, DMA Product Review Program, 1 October 1982.

[2]DMA Manual 8570.1, DMA Product Maintenance System Manual, January 1988.

User's comments generally point out specific errors, but can suggest areas of potential improvement. Because of the operational experience of the suggestions, these suggestions are of vital assistance to DMA in suggesting improvements on DMA products.

Annual Survey

Annually, DMA compiles a list of all validated DMA products. This list is called the DMA Required Items List.[3] This list is forwarded to the U & S Commands for revalidation of requirement. This validation is a simple yes/no indication as to the continued utility of the products on the list. If a product line is no longer required by any Command, DMA will remove it from inventory and will no longer maintain the product line. An example of this occurred as a result of the large format (3.5' x 5.5') printing of Operational Navigation Charts (ONC) and Tactical Pilotage Charts (TPC) which eliminated the military requirement for the small format World Aeronautical Charts (WAC) and Pilotage Charts (PC). This removal from inventory completes the life cycle of that particular product.

After the Required Items List is updated, certain products are selected for more extensive review by the user for the purpose of potential improvement. This product

---

[3]DMA Instruction 8052.4, DMA Product Review Program, 1 October 1982.

review may be in the form of a questionnaire or a prototype review. The most frequent review is the questionnaire. It is designed to determine exactly how the product is being used and identify areas of potential improvement. The questionnaires are only sent to those U & S Commands that validated a need for the product. Ninety days are allocated for the U & S Command's completion of the questionnaire. After all replies are received, the DMA program manager for each product line consolidates the findings and makes recommended changes (as appropriate) through Hq DMA to the U & S Commands for their final approval. Upon approval, DMA prepares changes to the Product Specifications. These changes are published and become a permanent part of the product specification.[4] Changes are automatically mailed to all holders of the product specification for their information and adherence.

Some proposed changes may be so complex or difficult to comprehend that an actual prototype product is produced to be evaluated against an existing product. A problem of feature clutter was identified by USAF/TAC resulting from the vertical obstruction portrayal criteria of 200' for the ONC. DMA proposed reducing the portrayal criteria to 500'. In order to properly evaluate this proposal, prototype ONCs were produced using the new

[4]DMA Manual 4070.10, DMA Configuration Management Program, 6 September 1984.

selection criteria. These prototypes are used in actual mission conditions so that their utility in combat conditions can be determined. Most prototypes contain a composite of suggested changes that users have suggested through user comments, the questionnaires, or conversations with various DMA personnel. The suggested changes must be approved by all validated users before the change is implemented. The suggested change may be acceptable for one intended use, but unacceptable for others. Thus, the change is evaluated unacceptable overall. If there are many changes incorporated into a prototype, each proposed change must be evaluated. After all other evaluations are received, the program manager consolidates the results. Those suggested changes which were evaluated as acceptable to all users are incorporated into a final prototype, which is sent out for final evaluation.

Assuming the final prototype is acceptable to all users, the appropriate change notices are published for the product specification. Distribution is made to all holders of the product specification for their information and adherence.

CHAPTER VI

CONCLUSION

Current Procedures

In the preceding four chapters, I have consolidated the major DMA responsibilities relative to the production and maintenance of mapping, charting, and geodetic (MC&G) products. These products may be lithographic, photographic, or digital data. Though these products have different formats and satisfy many different intended uses, they all have the same "life cycle."

The life cycle begins at the identification of an MC&G requirement to support a new weapon system or weapon system trainer. DMA personnel work with the new system's program management personnel in defining the MC&G requirement. A prototype product is produced and evaluated as the new system is being developed. A final product specification is developed and documented in sufficient time to permit the production of significant quantities of the product before the weapon system has achieved full operational capability.

The users are asked to identify where they require each product and in what priority. This information, plus the availability of adequate source material to produce a product, is used to develop the POM and FY production program. After the production program is established, actual production assignments are made. The production process includes the preparation of a source package and the actual data collection. The data collection phase has both in-process and end-process quality control inspections to ensure the production of quality DMA products.

Digital data products are efficiently stored in the Cartographic Data Base (CDB). Other CDB responsibilities include physical protection, retrieval, and distribution of digital data products.

The ongoing product review process determines the continued utility and potential areas of improvement for DMA products. User comments and annual surveys are tools used by DMA to determine the best overall product to meet the user's MC&G requirements. If a product is no longer required by a U & S Command, it is removed from inventory and is no longer maintained--thus, completing its life cycle.

The importance of DMA produced MC&G data has increased significantly with the advent of sophisticated weapon systems, weapon system trainers, and automated mission planning systems. As requirements for MC&G data have been identified, DMA has aggressively pursued the most cost effective procedures to produce sufficient quantities of high quality data to meet these requirements. Emphasis has always been on satisfying the user's needs. DMA is a support agency of the DOD, which is tasked with the production of MC&G products to satisfy military operational and training needs. The current DMA product "life cycle" has evolved into an extremely efficient procedure to ensure the military MC&G needs are identified/documented and quality products are produced/maintained.

Production Trends[1]

In 1982, DMA embarked on an extensive mandatory conversion program that will give DMA a modernized production capability. This Exploitation Modernization Program (EMP) will provide, by the early 1990's, a digital production capability that will theoretically improve flexibility and enhance DMA's ability to respond to user needs.

The EMP has two phases: MARK 85, which delivered new production capabilities between 1985-1988; and MARK 90, which will achieve full operational capability in 1992. The EMP has not changed, nor does it propose to change, the traditional suite of products now distributed by DMA: paper maps and charts, digital terrain elevation and feature analysis data, and image-based products. It does, however, as a by-product, generate and store digital in-process files containing the information displayed on its traditional products.

---

[1]This entire section has been derived from a Draft DMASC Concept Proposal, The DMA Distributed Production Architecture Program (MARK 90.1), approximate date July 1987.

DMA's customers have growing requirements for digital MC&G data to support their emerging systems. Although many of these requirements need further examination and refinement, the trends and implications to DMA are perfectly clear: DMA must evolve a new suite of digital products designed to satisfy these emerging requirements and turn its production energy toward producing them.

DMA's customers are showing growing digital sophistication. High performance graphics systems, some of which are spin-offs from DMA's EMP, are becoming available off the shelf and are providing DMA customers with the ability to tailor and exploit MC&G data in unexpected ways. Moreover, many users of DMA data, especially in the functional areas of intelligence fusion and analysis, mission planning, and command and control, are able to add value to the foundation MC&G data provided by DMA.

These developments--the modernization of DMA with its in-process digital files and exchange standards, the growing requirements for digital MC&G data, and the opportunity for DMA to benefit from value added in the field--have led to an extension to the Modernization Program that is called the DMA Distributed Production Architecture or MARK 90.1. MARK 90.1 provides for distribution, manipulation, and exploitation of digital

MC&G data bases to and in the field, where hard copy and digital products could be tailored to the local situation and commander's orders. Value added in the field would be looped back to DMA, in turn benefitting all other users.

Concerns

The concept of a Distributed MC&G Data Base is not particularly revolutionary. However, the degree to which DMA is prepared to place its basic cartographic data and extraction routines into the field represents a dramatic change. DMA historically has provided specific product data to the user to satisfy specific intended uses. The distribution of raw data base holdings to the user raises the following major concerns.

The current product "life cycle" has a well defined procedure for determining MC&G requirements and then determining the most cost effective procedures to produce the product. The proposed MARK 90.1 concept offers the user the opportunity to add, delete, or change data in the DMA data base. Adding data changes the requirements definition. If it is a valid requirement, the product specifications should be revised and the new data should be collected by DMA during the production phase. If data is deleted by one user, it must not be eliminated from the DMA master data base without all users' approval. If data is changed, then DMA will lose control of the quality of the data. DMA must be held responsible for the quality of its MC&G data base. If users are permitted to add or change data, the ability to hold DMA accountable for the quality of the data base will be lost.

Recommendation

DMA has been successfully satisfying the military operational and training requirements for years. The procedures for MC&G requirements definition, production procedures, data base management, and product reviews have evolved into the most efficient method for developing, producing, and maintaining the required MC&G poducts. These principles apply in today's environment of specific product production, and it is my contention that it must not be abandoned in a Distributed Data Base Concept.

In my judgement, the Distributed Data Base should be considered to be a product. Granted this product must satisfy every intended military use, but I contend it is still a product. It has a requirements definition, which is a composite of the most stringent user requirements. No changes to this definition should be made without the approval of all validated users.

Once a requirements definition is changed, DMA should be tasked to determine the most cost effective production technique to accomplish the change. Value adding should be restricted to those few items which DMA cannot provide.

DMA must remain responsible for the quality of the products they produce. If this data base is a product, then procedures must be developed to ensure the continued integrity of its data.

BIBLIOGRAPHY

Deputy Secretary of Defense Memorandum, Subject: Implementation of August 1985 Program Decision Memorandum for Defense Mapping Agency (DMA) Programs, 6 June 1986.

DMA Fiscal Year 1988-92 Joint Manpower Program (Systems Center).

DMA Instruction 8050.3, Area Requirements and Product Status (ARAPS) System, 23 June 1980.

DMA Instruction 8050.4, Subject: Submission and Validation of Area Requirements for Mapping, Charting, and Geodesy Standard Products and Services, 17 June 1987.

DMA Instruction 8052.4, DMA Product Review Program, 1 October 1982.

DMA Instruction 8130.1, Subject: DMA Product Specifications 9 April 1984.

DMA Manual 1434.3, DMA Performance Management System (PMS) Manual, November 1986.

DMA Manual 4070.10, DMA Configuration Management Program, 6 September 1984.

DMA Manual 8130.2, DMA Production Documentation Manual, June 1987.

DMA Manual 8570.1, DMA Product Maintenance System Manual, January 1988.

DMA Product Specifications for Digital Feature Analysis Data (DFAD) Level 1 and Level 2, PS/1CE/200 and PS/1CG/200, Second Edition, April 1986.

DMA Product Specifications for Digital Terrain Elevation Data (DTED), PS/1CD/200 and PS/1CF/200, Second Edition, April 1986.

DMA Product Specifications for Terrain Contour Matching (TERCOM) Data Base, PS/4GE/100, PS/4GF/100, and PS/4GG/100, Second Edition, May 1985.

DMAAC PP SOP 7045.1, Subject: Preparation of DMAAC Program Objectives Memorandum (POM), 18 September 1987.

DMAAC Regulation 8501.1, DMAAC Integrated Status Reporting System (ISRS), 16 August 1982.

DMASC Concept Proposal (draft), The DMA Distributed Production Architecture Program (MARK 90.1), approximate date July 1987.

DPI SOP 8530.3, VOD Feasibility and Planning Function, 30 June 1986.

DPM SOP 8421.5, Image Manipulation System (IMS) Procedures, February 1983.

DSM SOP 8422.1, CDB MACS Maintenance Procedures and Responsibilities, June 1987.

SDA SOP 8132.3, Automated Map Information File (AMIF), 12 October 1987.

SDA SOP 8203.3, Preparation of Source Packages for Vertical Obstructions, 31 July 1981.

SDA SOP 8600.1, Chart Updating Manual, 18 December 1985.