MAPPING, CHARTING AND GEODETIC NEEDS FOR REMOTE SENSING DATA

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Abstract

The Defense Mapping Agency (DMA) provides mapping, charting and geodetic (MC&G) support to the Department of Defense (DoD). Some MC&G products utilize remote sensing data from satellites such as Landsat. DMA's commercial imagery requirements and information on DMA's Strategic Direction are described. DMA technical and business points of contact are provided.

DMA Overview

The Defense Mapping Agency (DMA) was formally established in July 1972 and was designated as a Combat Support Agency by the Goldwater-Nichols Department of Defense (DoD) Reorganization Act of 1986. DoD Directive Number 5105.40, dated 6 December 1990, identifies the DMA charter which describes its mission, authorities, responsibilities, functions, and relationships.

DMA is chartered to provide support to the Office of the Secretary of Defense; the Military Departments; the Chairman, Joint Chiefs of Staff and Joint Staff; the Unified Commands; the Defense Agencies; and other Federal Government Departments and Agencies on matters concerning mapping, charting, and geodesy (MC&G). DMA's charter includes preparing, coordinating, and issuing standards for MC&G products; representing DoD in national and international MC&G standardization activities; providing technical guidance to all DoD components to ensure standardization and interoperability of systems requiring MC&G support; and advising the Defense Acquisition Board on MC&G issues. The charter also identifies DMA as the primary DoD action office for all purchases of Land Remote Sensing Satellite (Landsat) and Systeme Probatoire d'Observation de la Terre (SPOT) remote sensing data by the Military Departments and Defense Agencies.

DMA operates under the direction, authority, and control of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence

(ASD/C3I). The Chairman of the Joint Chiefs of Staff is authorized to communicate directly with the Director, DMA, and may task the Director, DMA to the extent authorized by the ASD/C3I.

DMA Products

DMA products support a wide variety of uses including strategic and tactical combat operations; combat mission and route planning; training and simulations; air, sea, and land navigation; command, control, communications, and intelligence operations; wargaming; modeling and simulation; drug interdiction; and command briefing aids. Many products are either imagery-derived (produced from imagery that is not a part of the final product) or imagery-based (produced with imagery as part of the final product). The following is a sample of DMA's imagery-derived and imagery-based products (a complete list of DMA products can be found in reference a.):

Imagery-Derived Products:

Digital Terrain Elevation Data (DTED)
Digital Feature Analysis Data (DFAD)
Harbor and Approach Chart (HAC)
Coastal Chart
Air Target Chart (ATC)
Joint Operations Graphic (JOG)
Terrain Contour Matching (TERCOM) Maps
City Graphic
Topographic Line Map (TLM)
Interim Terrain Data (ITD)
Tactical Terrain Data (TTD)*
Vector Smart Map (VMap)*
Urban Vector Smart Map (UVMap)*

Imagery-Based Products:

Controlled Image Base (CIB)
Point Positioning Data Base (PPDB)
Image Map
Aim Point Graphic
Gridded Airfield Photograph (GAP)
Gridded Installation Photograph (GIP)

*Denotes a developmental or prototype product

DMA Commercial Imagery Requirements

Today, DMA purchases most satellite imagery for DoD use. DMA's role as the primary DoD action office for procurement of Landsat and SPOT remote sensing data is expected to expand in the future, recognizing the growing number of commercial imagery sources. DMA has developed a set of commercial imagery requirements to assist current and future commercial developers to understand DMA's needs for imagery. While DMA is not in a position to define the imagery requirements for other DoD elements, in many cases, DMA's requirements will satisfy other users.

Imagery and imagery support data must satisfy certain requirements for DMA use. In times of crisis, DMA may use imagery that does not meet the full set of requirements. Generally, the fewer requirements satisfied, the lower the utility for DMA applications. DMA's imagery requirements are covered under the following topics:

a. Standard Media and Data Formats

b. Cloud Free Scene Content

c. Image Quality

d. Area Collection Closure Rate

e. Large Area Coverage

f. Stereoscopic and Monoscopic Acquisition

g. Imaging Sensor Calibration

h. Geolocation Capability

i. Spectral Bands

a. Standard Media and Data Formats

DMA expects to process all imagery in softcopy on magnetic media. The majority of DMA production imagery will be obtained from D2 Cassettes (D2C). Please contact DMA for specific information regarding D2C tape media and format. DMA also has a capability to input and process a small volume of imagery on other media, such as digitized hardcopy, 9-track computer compatible

tapes, Compact Disk-Read Only Memory (CD-ROM), Very Large Data Storage (VLDS) cassettes, and 8mm cassettes.

DMA is upgrading its Digital Production System to accept imagery on these media through a Front End Processing element. The Front End Processor is currently in Preliminary Design. Candidate source types and data formats are being compiled. Final descriptions will be published sometime in 1995, during Critical Design. The following is a list of expected imagery format standards to be supported:

Federal Information Processing Standards (FIPS)

National Imagery Transmission Format Standard (NITFS)

Tagged Image File Format (TIFF)

b. Cloud Free Scene Content

Complexity of exploitation increases proportionally with cloud cover. The clearer the imagery, the easier the task of compilation. DMA has the limited ability to exploit cloudy imagery, although the difficulty of managing and exploiting multiple layers of imagery prohibits efficient operations.

DMA's cloudfreeness goal is 100% over the geographic area of the product. The criterion for image acceptability varies regionally, reflecting the cloud free values of historical weather patterns ranging from 80-100% clear in the temperate zones to 50% or lower in the tropics. Although not a DMA requirement, use of weather data during collection planning is helpful to achieve efficiency in the acquisition of imagery of this quality.

c. Image Quality

DMA studies performed over the past few years have reiterated the need for one to five meter ground sample distance (GSD) panchromatic imagery in support of MC&G requirements. One meter GSD imagery which supports previously mentioned products will be needed to meet the increasingly detailed feature identification and attribution required for new digital products and geographic databases. Five meter GSD imagery will satisfy new requirements for worldwide geocoded imagery data (CIB), thus supporting military mission planning systems.

d. Area Collection Closure Rate

Collection rate requirements fall under two categories: first, the timelines for the acquisition and delivery of a single or small number of images; and second, the timelines for complete collection over a substantial geographic area.

During crises, minimizing the time from tasking, through collection and delivery is the driving requirement. DMA's ability to produce quick response products is limited by imagery availability. Numerous production operations, both standard and work-around, are brought into play using any available source to generate products for crisis support.

In a peacetime scenario, area closure rate is the dominant factor. Imagery needs to be collected within a few months to a year from initial DMA request. DMA needs to have recent imagery in archive or have the capability of rapidly collecting a large contiguous area. The reasons for this are to satisfy product currency requirements (typically less than three years) and to provide temporally consistent data to facilitate automated extraction tasks and tone-matching for image based products.

In summary, the ideal collection system is one robust enough to handle large volumes of globally distributed requirements on a daily, steady-state basis, yet capable of occasional surge operations over a local region to satisfy high priority crisis collection.

e. Large Area Coverage

The activities of planning for and exploiting imagery for MC&G products is simplified through the use of imagery covering large geographic areas. While the exploitation of a number of mosaicked, smaller images is possible and the overhead in merging these smaller images together may be problematic, the generation of MC&G products with a high degree of absolute and relative accuracy requires knowledge of the relationships of the image pixels to the ground, as well as to each other. Imagery scenes that cover large geographic areas would eliminate the need to triangulate numerous smaller scenes into larger production blocks. Typical MC&G production block sizes of 10,000 square kilometers or larger are desirable.

f. Stereoscopic and Monoscopic Acquisition

Photogrammetric extraction of MC&G information which can be referenced absolutely to the earth requires the measurement and transformation from two-dimensional image space into three-dimensional object space. This can be done two ways: using a stereoscopic image model and extracting three-dimensional coordinates through stereoscopic intersection, or using a single (monoscopic) scene with externally derived terrain data and intersecting a single image ray with the ground.

Currently, the majority of DMA's image exploitation relies on stereoscopic model extraction to generate products. DMA operations populate an MC&G database of feature and elevation data as an intermediate step to product generation. This forms a planimetric base which supports future monoscopic revision for currency. Once the world's landmass is covered by stereoscopic imagery, then DMA's collection strategy will shift from predominately stereoscopic to primarily monoscopic imagery.

The preferred stereo model for visible imagery requires collection on a single pass. There are two reasons for this. First, it guarantees similar scene content for both images, easing the task of feature identification and extraction. Second, the geometric errors associated with two images on the same pass are easier to model and remove than those from two independent images.

g. Imaging Sensor Calibration

DMA requires interior orientation information beyond the traditional frame model parameters of focal length, principal point offsets, and radial distortion. The reconstruction of the ray from the sensor focus to a given pixel in the array of a scanning imaging satellite is a function of vehicle position, attitude, orbital motion, scan rate, Charge-Coupled Device (CCD) read-out, etc. The ability to radiometrically and geometrically reconstruct an accurate electro-optical image requires the definition of a mathematical model to describe the process, and the calibration activities (both pre-flight and on-orbit) to estimate performance during acquisition.

h. Geolocation Capability

The need to determine accurate ground coordinates from imagery permeates this list of requirements. All of the factors described previously, plus accurate knowledge of the sensor position and orientation, support DMA's need for a geolocation capability.

Absolute geolocation is achieved two ways. Either it could be built into the collection system (position, attitude, and calibration knowledge), or it is added later (parameter refinement via ground control and/or block adjustment). Usually, a combination of the two is employed. DMA performs post-processing adjustments to improve the collector's stand-alone positioning capability. Generally, the better the collection system performs with respect to absolute positioning, the easier it is for DMA to perform exploitation. For non-DMA applications such as urban planning, the user typically provides ground control through surveying techniques. However, it is unrealistic to assume the existence of geodetic control over DMA's worldwide area of responsibility.

The required levels of accuracy vary by product, but can be generalized as follows. Large to medium scale products require absolute accuracies on the order of 23/17* to 61/61 meters on the World Geodetic System 1984 (WGS 84). Relative accuracy requirements for most MC&G products are 9/13 meters. These relative and absolute accuracy requirements influence the geolocation capabilities of products such as image mosaics.

*Numbers quoted represent horizontal circular error (CE) and vertical linear error (LE), respectively, and are in meters at the 90% confidence level.

i. Spectral Bands

DMA's analysis of its product requirements and sensor technologies indicates that panchromatic imagery would be DMA's primary source. Currently, DMA's use of imagery beyond the panchromatic range (i.e., multispectral imagery) is limited but expected to increase in the future. Today, DMA uses MSI to assist in the identification of shallow water and terrain categorization for some product lines. In the future, MSI is expected to be used for new product lines such as the TTD. In poor weather regions, synthetic aperture radar imagery may best support MC&G products.

DMA Strategic Direction

The "Strategic Direction for the Defense Mapping Agency, A Vision for the 21st Century" includes the following specific statements regarding DMA's future remote sensing requirements:

"Given unpredictable military operating areas, usable source material on a global basis must be immediately available for use in production."

"We will need new aggressive strategies to ensure adequate hardcopy, digital, and imagery source materials are available to support production."

"Secondary sources, such as native maps and charts, and international and private sector imagery will also be exploited to ensure currency, close gaps in coverage, and satisfy crisis requirements."

"Our strategy will be to acquire source materials from all available sources."

DMA Points of Contact

Business-oriented and technical inquiries may be addressed to:

Director
Defense Mapping Agency (National Imagery & Mapping Agency)
ATTN: Public Liaison Division
(Mail Stop A-11)
8613 Lee Highway
Fairfax, Virginia 22031-2137
TELEPHONE: (703) 275-8409

References

a. DMA List of Products and Services, DMAL 805-1A, March 1994.

b. Digitizing the Future, Fourth Edition.

c. Strategic Direction for the Defense Mapping Agency, A Vision for the 21st Century, February 1994.

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Previous	Co-Keynote Speaker: Mr. Doug Smith, Deputy Director, Defense Mapping Agency, Defense Mapping Agency and the Commercial Sector
Next	Mr. Dan Sibbet, Autometric, Inc., Emerging Business Models for Commercial Remote Sensing

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