AD-A284 739

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

...n is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, ...ting and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this ...cing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson ...nd to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

2. REPORT DATE
September 1994

3. REPORT TYPE AND DATES COVERED
Scientific Paper

4. TITLE AND SUBTITLE
Geospatial Data - Critical to Combat Operations

5. FUNDING NUMBERS

6. AUTHOR(S)
Walter E. Boge

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Topographic Engineering Center
ATTN: CETEC-PAO
7701 Telegraph Road
Alexandria, VA 22315-3864

8. PERFORMING ORGANIZATION REPORT NUMBER
R-239

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release;
distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Since the inception of armed conflict, knowledge of the battlespace environment (i.e., terrain and weather) has always been a critical factor in determining the outcome of combat operations. With today's modern weaponry, represented by laser-guided bombs, nap of the earth aircraft, and high-speed armor; knowledge of the battlespace environment is more critical than ever to combat success. Every new weapon, command and control, and intelligence system has a requirement for terrain information. The rapidity and lethality of today's combat operations require commanders at each echelon to know where they are, where their troops are located, and the most likely positioned of enemy forces--all on a common three-dimensional reference system. Planning and maneuver operations require a three-dimensional perception of the battlefield, i.e., the associated terrain and natural (e.g., vegetation) or manmade (e.g., road networks) features and targets. Achieving this perception necessitates the creation of a data base that depicts these features and allows them to be manipulated, combined, and analyzed. Also, battle or naturally induced changes, such as a blown or flooded bridge, need to be incorporated into the geospatial data base and their impact on operations determined (e.g., route re-planning).

14. SUBJECT TERMS
battlespace environment, command and control, and intelligence system

15. NUMBER OF PAGES
11

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
unclassified

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow It is important to ***stay within the lines*** to meet ***optical scanning requirements***.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	- Contract	PR	- Project
G	- Grant	TA	- Task
PE	- Program Element	WU	- Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

- **DOD** - See DoDD 5230.24, "Distribution Statements on Technical Documents."
- **DOE** - See authorities.
- **NASA** - See Handbook NHB 2200.2.
- **NTIS** - Leave blank.

Block 12b. Distribution Code.

- **DOD** - Leave blank.
- **DOE** - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
- **NASA** - Leave blank.
- **NTIS** - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

GEOSPATIAL DATA - CRITICAL TO COMBAT OPERATIONS

Walter E. Boge
Director

U.S. Army Topographic Engineering Center
7701 Telegraph Road
Alexandria, Virginia 22315-3864
(703) 355-2600, Fax: (703) 355-3176

Since the inception of armed conflict, knowledge of the battlespace environment (i.e., terrain and weather) has always been a critical factor in determining the outcome of combat operations. History is replete with stories of how successful warriors used this knowledge for selecting optimum locations for attack, placing artillery for maximum coverage and identifying choke points and likely avenues of approach/escape. The more detailed and timely the terrain and weather information was, the more effectively it could be exploited. And, when intelligence information of enemy location and size could be overlayed on the terrain, the force multiplication effect was exponential.

With today's modern weaponry, represented by laser-guided bombs, nap of the earth aircraft, and high-speed armor; knowledge of the battlespace environment is more critical than ever to combat success. Every new weapon, command and control, and intelligence system has a requirement for terrain information. The rapidity and lethality of today's combat operations require commanders at each echelon to know where they are, where their troops are located, and the most likely positions of enemy forces--all on a common three-dimensional reference system. Planning and maneuver operations require a three-dimensional perception of the battlefield, i.e., the associated terrain and natural (e.g., vegetation) or manmade (e.g., road networks) features and targets. Achieving this perception necessitates the creation of a data base that depicts these features and allows them to be manipulated, combined, and analyzed. Also, battle or naturally induced changes, such as a blown or flooded bridge, need to be incorporated into the geospatial data base and their impact on operations determined (e.g., route re-planning).

Traditionally, the geospatial reference used by combat commanders has been the standard, hard-copy Topographic Line Map (TLM). Drawn to cartographic specifications--based on scale, projection, required information, and the draftsman's ability to accurately place a point or line on a piece of paper--the TLM contains a host of relevant and sometimes irrelevant information. Each country has developed different standards and presents different amounts of data on their maps. And, in many countries, maps are considered such a vital source of information that they are classified or controlled by copyright. The TLM is an analog version of a geospatial data base. Every piece of information depicted on the map has a two-dimensional, horizontal coordinate and a name or symbol. The elevation, or Z value, is normally interpolated from contours by the user. The production of TLM's is a slow, labor-intensive process requiring considerable cartographic and geodetic expertise. As a result, TLM's are usually out of date.

The Defense Mapping Agency (DMA) is charged with overall responsibility for providing Mapping, Charting and Geodesy (MC&G) data to the U.S. Armed Forces. It responds to area coverage requirements established by U.S. Joint and Unified Commands around the world, prioritized by guidance provided through the Joint Chiefs of Staff (JCS) and the Assistant Secretary of Defense for Command, Control, Communications and Intelligence (ASD-C^3I). MC&G product types and scales are defined by each service staff element and coordinated through DMA Headquarters into a set of "standard" products. Needless to say, the overall service MC&G requirements worldwide far outstrip DMA's production capability. DMA does a fantastic job in attempting to meet high- priority requirements and is very proactive in trying to anticipate mapping requirements as new military crises and international emergencies arise. The bottom line, however, is that DMA does not have the resources to satisfy the overall need.

At this point, I will focus on the Army's requirements for MC&G geospatial data and the status of that data. As opposed to the Air Force and Navy, which generally have medium and small scale (1:250,000 and smaller) MC&G requirements to support "strategic" type weapons (e.g., ICBMs, Bombers and Cruise Missiles), the Army's and the Marine Corps' tactical primary mapping needs fall in the 1:50,000 and larger scale range. Until recently, much of the nation's high-priority MC&G requirements centered around Cold War considerations. Thus, the northern hemisphere is reasonably well mapped at the 1:250,000 and smaller scales; although even these products are rapidly aging (see Figure 1). On the other hand, most of the world (except for specific regions in Europe and Korea) is not very well covered with 1:50,000 scale products. (See Figure 2.) This lack of large-scale coverage was emphatically evident during Operations Desert Shield, Provide Hope, Provide Comfort, and now in Rwanda.

I need now to refer back to today's new warfighting hardware and the need to support these military systems with geospatial (read map) data. These systems all require these data in digital, not analog, format. DMA has recognized this requirement and invested very heavily in transforming their production plants to an all digital operation. However, that transformation is not yet complete. To provide a partial solution, DMA has produced digital equivalents of TLM's, called the ARC Digitized Raster Graphic (ADRG), which is essentially a rasterized TLM that can be displayed on a CRT. This digital product is also geographically limited to areas mostly in the northern hemisphere (See Figure 3). The ADRG is often referred to as a "dumb map" in that, although digital, the feature data cannot be manipulated and it cannot be used directly to provide a 3-D visualization of the terrain. DMA also has validated an Army requirement for Tactical Terrain Data (TTD), which provides vectorized digital map overlays (i.e., vegetation, lines of communication, hydrology, soils, and obstacles), and plans initial production of this product in 1996. Lastly, the Army has been successfully exploiting another DMA digital product, called Digital Terrain Elevation Data (DTED), to support its contingency needs. However, this elevation data base, which was produced to support strategic weapon requirements, is at a medium-scale equivalent density (1:250,000); not at the 1:50,000 scale density the Army requires (See Figure 4).

Given recent experiences, it is likely that the Army can be called upon to fight (or carry out peace keeping operations) anywhere in the world on very short notice; particularly in third world areas. It can also be asserted that map data (analog or digital) in these areas (should it exist at all) would be of medium or small scale, out-of-date, and of questionable accuracy. To overcome this deficiency, the Army has undertaken several development efforts to provide tactical commanders with quick response, large-scale map substitutes and terrain visualization. The goal is to rapidly establish an initial geospatial data base (or extend an existing data base) to support planning and maneuver operations, until the time when DMA production assets can be directed to support the operation with standard products.

The objective of this program is to quickly produce, at the theater level, an accurate, large-scale otho-rectified digital image map with a grid overlay that can be generated in hours and field reproduced in hard copy. This digital raster formatted map also needs to be transmitted to deployed units for display and targeting. The basis for achieving this capability is a digital photogrammetric device called TIES, for Terrain Information Extraction System. TIES can automatically correlate stereo-imagery to produce a dense array of elevation points oriented to a prescribed datum. Using the elevation information and knowledge of the orientation of the imagery, each picture element (pixel) is then transformed to remove geometric and relief distortion; thus producing an ortho-photograph. The TIES can accept imagery from a multitude of sensors (frame, panoramic, scanners, etc.) and has demonstrated its utility on several projects.

Having full knowledge of the geometry of the imagery and the surface configuration, the TIES can produce a three-dimensional image perspective transformation (IPT) for any number of points in space; thereby providing a fly-through capability. As more time is allowed, the TIES operator can manually generate terrain feature files from the stereo model using a Geographic Information System (GIS) and a "floating digital dot." The GIS allows merging these data files with DMA-produced digital data (if it exists) and the overlay of intelligence information (ICONS). Figure 5 shows a photograph of the TIES. The beauty of the TIES is its flexibility in handling different types of sensor imagery and the ability to generate digital terrain information to any scale. The input imagery can be either hard copy or digital. In the case of the former, a TIES component can precisely scan and digitize the imagery down to 7 1/2 micrometers in resolution.

Army field commanders have stated formal requirements for a field capability to rapidly produce image map substitutes and 3-D visualization. In response, the Army Staff has funded the development of two prototype systems called TIIP (Topographic Imagery Integration Prototype). TIIP constitutes a total system for receiving and processing a wide variety of image data, generating map-substitute and terrain visualization products, and providing hard copy and digital outputs. The heart of TIIP is the two TIES components discussed previously.

Additional components are computer processors and file servers that contain software to process commercial imagery (ERDAS) and establish a geospatial data base (ARCINFO). Hard-copy outputs are generated by another developmental item called the Quick Response Multicolor Printer (QRMP) for rapid production (10 minutes) of limited copies and a LINOTRONIC printer for press plate ready copies for lithographic, high-rate reproduction. A wiring diagram of the TIIP is shown in Figure 6.

The two TIIP systems are currently being built, with scheduled delivery to the XVIII Airborne Corps and Pacific Command starting in April 1995. In addition, a CONUS-based rapid mapping TIES/TIIP equivalent capability will be maintained at the Army Topographic Engineering Center to provide backup, "split-based" support for contingencies and emergencies. Once instituted, these systems will provide the Army with the capability to generate quick reaction, substitute map products and, as important, an ability for the field commander to visualize the battlefield. He will be able to walk or fly through the terrain, overlay important time sensitive intelligence and make critical decisions on how to fight the next battle.

Longer term R&D activities also are underway, oriented at developing automated methods for extracting terrain information. The goal is to extract natural and manmade features from remotely sensed data sources in three-dimensional space coordinates in near-real-time, such that data required to generate tactical decision aids can be produced in a timely manner. Then, computer programs to process this geospatial data will indeed give the warfighters a major leg up in their ability to visualize the battlefield (See Figure 7); to conduct realistic battlespace fly throughs to play "what if" exercises, and perform mission rehearsals that can significantly improve combat effectiveness and minimize casualty rates.

JOINT OPERATIONS GRAPHICS

1:250,000 SCALE

NOTE: Coverage shown is based on Defense Mapping Agency Catalog of Maps, Charts, and Related Products
Part 1 Volume 1 Aerospace Products (January 1992)
Part 3 Volume 1 Topographic Products (April 1993) and the best information available at time of revision.

revised 13 Apr 94

Figure 1

TOPOGRAPHIC LINE MAPS (TLMs)

1:25,000 SCALE
1:50,000 SCALE
1:63,360 SCALE
1:100,000 SCALE

NOTE: TLM coverage over Germany is available at both 1:50,000 scale and 1:100,000 scale.
From Defense Mapping Agency Catalog of Maps, Charts, and Related Products
Part 3 - Volume 1 Topographic Products (April 1993) and the best information
available at time of revision.

revised: 15 Apr 94

Figure 2

ARC DIGITIZED RASTER GRAPHICS (ADRG)

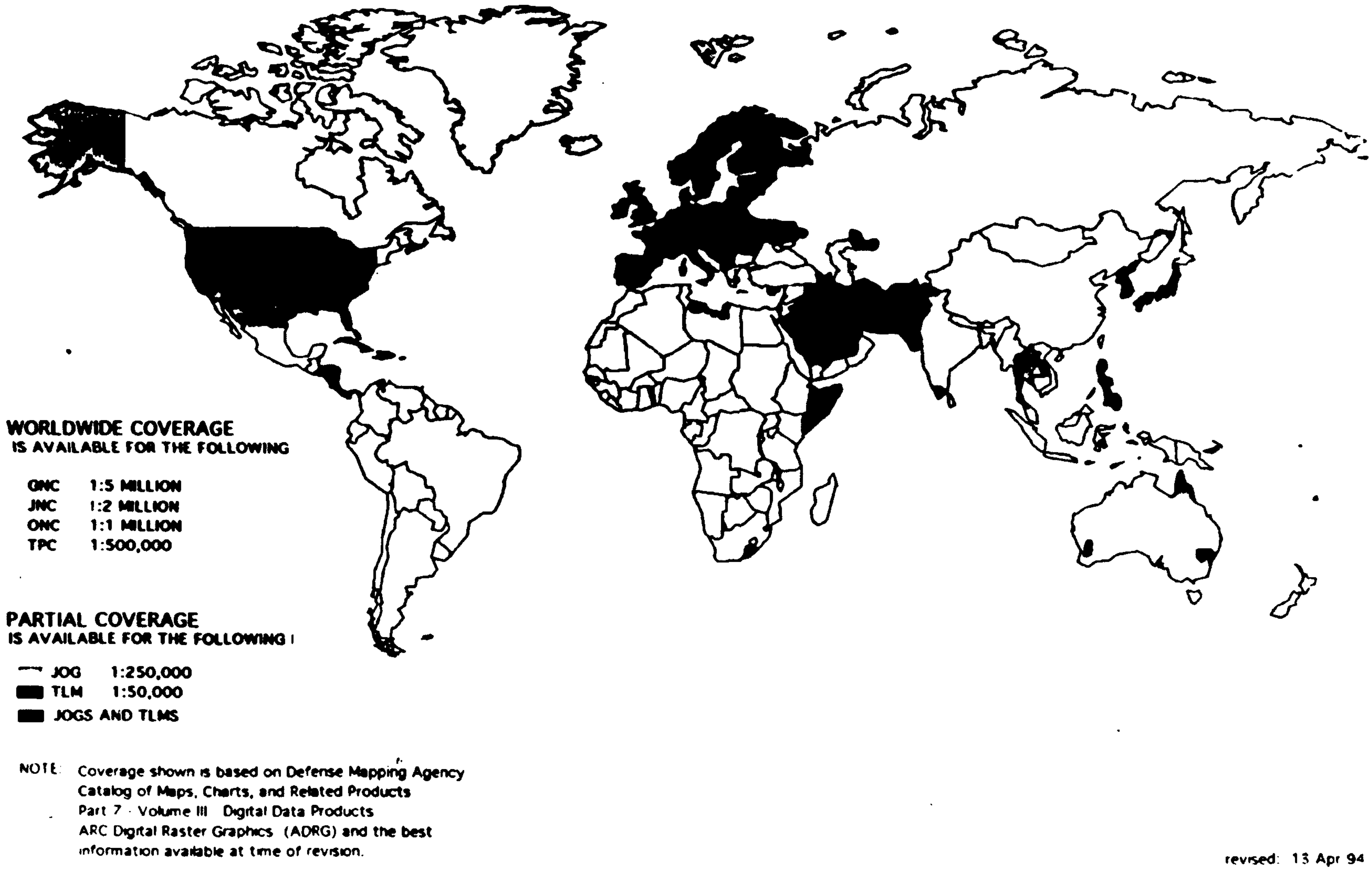
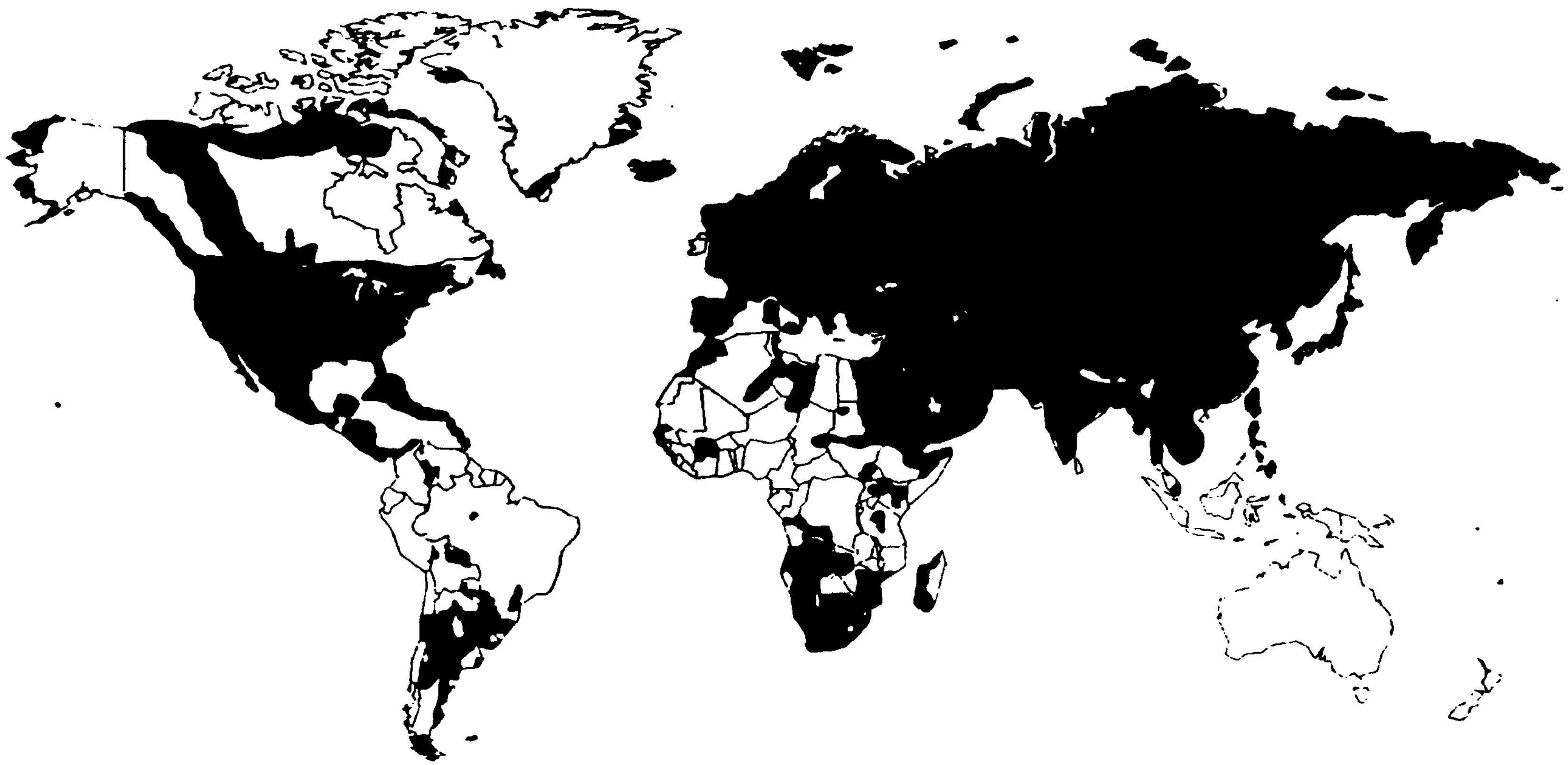


Figure 3

DIGITAL TERRAIN ELEVATION DATA (DTED)



NOTE: Coverage shown is based on Defense Mapping Agency Catalog of Maps, Charts, and Related Products Part 7 - Volume I Digital Data Products Terrain, Feature, and World Vector Shoreline Data (October 1992) and best information available at time of revision.

revised 14 Apr 94

Figure 4

Figure 5

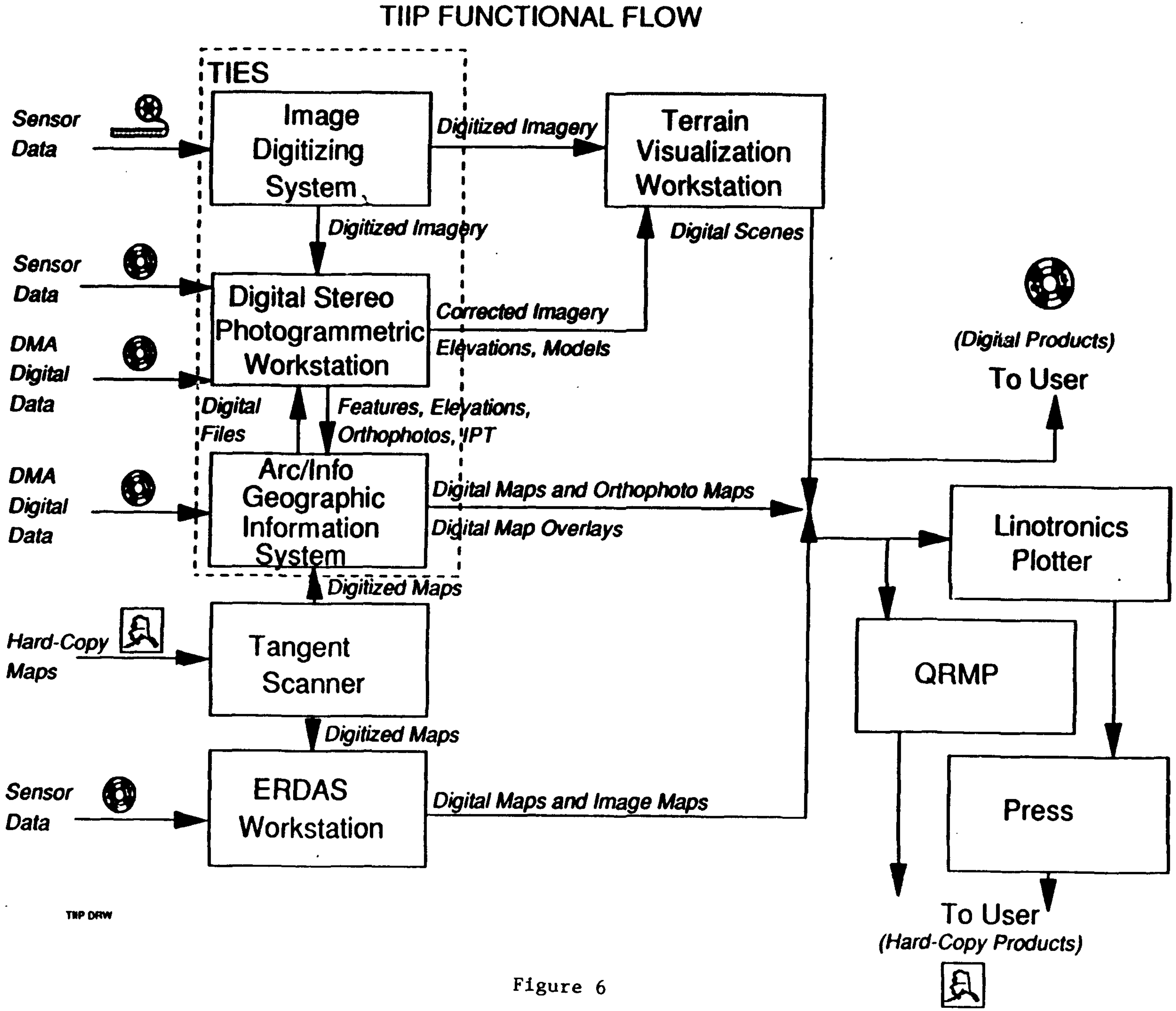

TIIP FUNCTIONAL FLOW
TIES
Sensor Data
Image Digitizing System
Digitized Imagery
Terrain Visualization Workstation
Digitized Imagery
Digital Scenes
Sensor Data
Digital Stereo Photogrammetric Workstation
Corrected Imagery
Elevations, Models
DMA Digital Data
(Digital Products)
To User
Digital Files
Features, Elevations, Orthophotos, IPT
DMA Digital Data
Arc/Info Geographic Information System
Digital Maps and Orthophoto Maps
Digital Map Overlays
Linotronics Plotter
Digitized Maps
Hard-Copy Maps
Tangent Scanner
QRMP
Digitized Maps
Sensor Data
ERDAS Workstation
Digital Maps and Image Maps
Press
TIIP DRW
To User
(Hard-Copy Products)

Figure 6

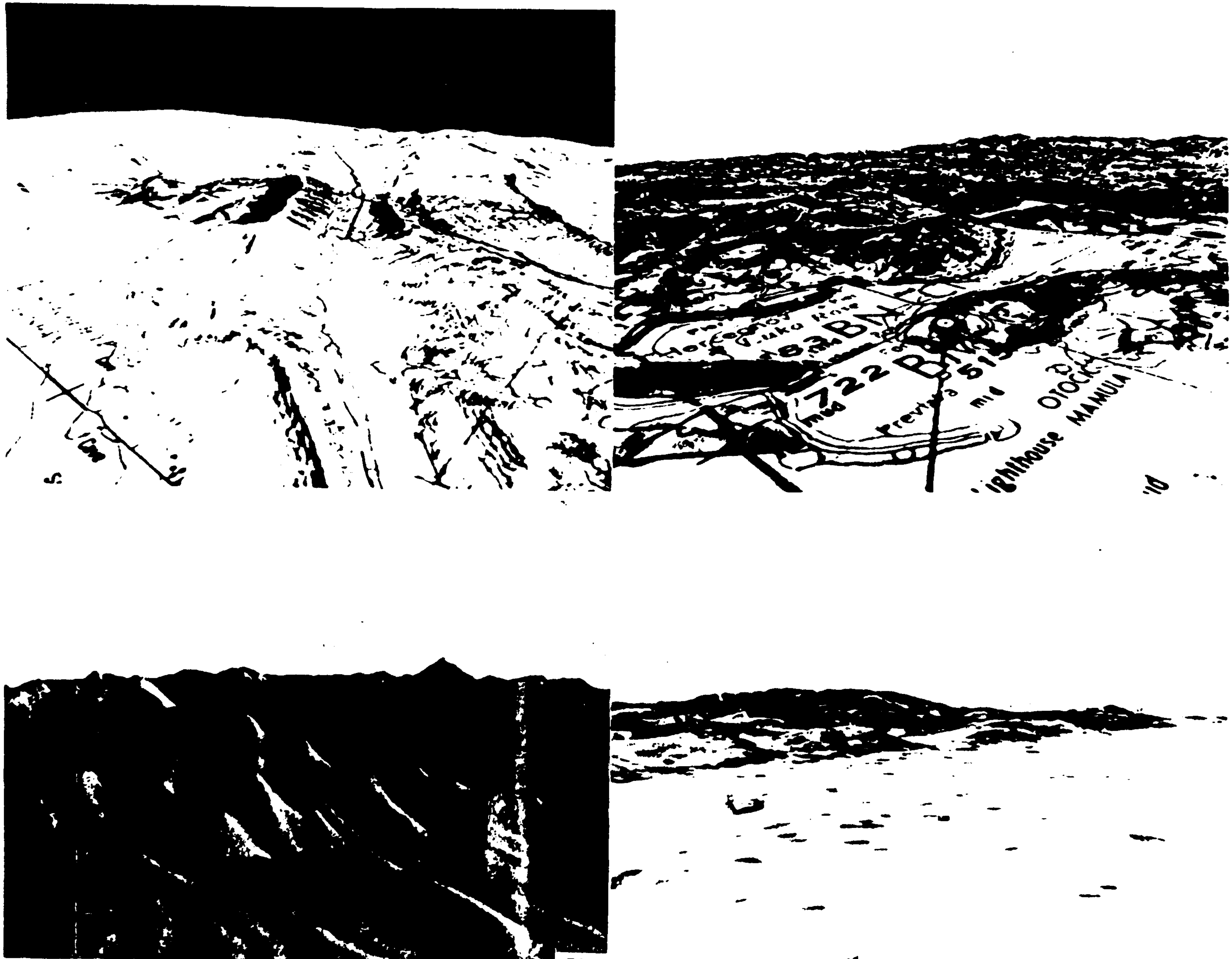


Figure 7