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SATELLITE IMAGERY GOES TO THE FIELD
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There was a time, not long ago, when topographic terrain support to Army forces in the field was either nonexistent or woefully inadequate due to the compilation date of the available map products. Field units were devoted to providing expedient products based on old source materials, when available, supplemented by aerial imagery, agent reports and personnel reconnaissance. If no base materials were available, "best guess" products were produced to fill gaps.

As recently as OPERATION URGENT FURY in Grenada, our soldiers went into combat with inadequate mapping support although, admittedly in that case, it was due more to bureaucratic SNAFU and the short duration of the operation itself rather than the unavailability of an adequate product. However, Grenada did provide one major lesson. It was the first direct exploitation of space derived digital imagery in support of actual combat. Landsat images were used to provide an overview of Grenada for planning and mission execution.

Today, in OPERATION DESERT SHIELD, we are seeing the first full-scale application of digital imagery to support the production of photo as well as conventional mapping products. These products are being produced by the Defense Mapping Agency (DMA) in its base plant facilities, the U.S. Engineer Topographic Laboratories' Terrain Analysis Center and Field Support Office, and topographic units in the field.

In facing the challenges presented by the OPERATION DESERT SHIELD deployment -- long-haul logistics, assemblage and operational control of a multicorps/multinational fighting force, operation in a highly hostile climate, threat posed by an opposing force which has demonstrated a willingness to employ lethal chemical weapons to gain a tactical advantage, management of a naval and land blockade, etc. -- the United States quickly came to realize that its mapping support was marginal. Some products were immediately available but were not of scales usable for tactical operations. Survey control was all but nonexistent in the operational area. Boundaries between Mid East nation-states were in dispute. Maps produced by several participants did not agree.

The DMA rose to the need. They rapidly reproduced additional stocks of maps which had been compiled in the past as a stop-gap measure until more current products could be provided. They turned to Landsat and SPOT satellite imagery for updating their compilation materials to generate a new map edition at tactical scales; however, the cartographic process is slow, even for the ever-modernizing

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DMA. To meet urgent needs for detailed information about the terrain, these same satellite images were used to create photo-maps to hold the line until cartographic products arrived.

The initial photo-maps produced lacked many of the refinements such as contours and cartographic aids which are called for in photo-map specifications, but they did provide a overview of the operational area -- the greatest need at the time.

Over in the Army, new problems were surfacing. Research and development programs and non-developmental equipment purchased to solve command, control and intelligence unit problems had become consumers of digital terrain information. Recent REFORGER testing in Germany had provided terrain information down to brigade level. Soldiers were using personal computers to process terrain information and other environmental data to plan and conduct training operations. They wanted this same data provided for the operational area.

For the past few years the U. S. Army Engineer Topographic Laboratories (USAETL) at Fort Belvoir, Va., has been involved in providing systems which use digital terrain data and the supporting digital terrain data in appropriate formats to field units. Just before DESERT SHIELD, USAETL's Commander and Director Col. David F. Maune formed a Field Support Office (FSO) to act as a point of contact for topographic units wishing to contact the Laboratories. The initial staffing of the FSO came from the Terrain Analysis Center (TAC), a production element for geographic information and terrain analysis, assigned to USAETL. TAC also was the Army's designated purchasing activity for in the acquisition of commercial satellite data for terrain analysis purposes.

During the initial phases of OPERATION DESERT SHIELD, 10 SPOT stereo pairs were procured to assist in detailed terrain analysis of high-priority areas. Forty-six 1:50,000-scale photo-map products were produced by EARTHSAT Corp., using DMA base maps for control. These products were provided to headquarters elements for planning, and copies were provided to the 30th Engineer Battalion (Topographic) for their planning and reproduction to support the deployed forces. In addition, the 10 off-nadir SPOT images were used to produce a 1:250,000-scale photo mosaic to provide broad area coverage. Off-nadir scenes, 1:50,000-scale map products and the mosaic were provided to the U.S. Marine Corps, who in-turn made lithographic copies for additional distribution.

Landsat data tapes were secured from DMA and provided to the EROS Data Center, where they were converted into 1:250,000-scale color composites for use by terrain analysts at USAETL in their mission to support the U.S. Army Intelligence and Threat Analysis Center (ITAC) with detailed terrain analyses of the operational region of OPERATION DESERT SHIELD. DMA also produced a series of Geocoded Landsat one-degree cells. These were obtained from DMA on

9-track tape for use in terrain analysis and for additional expedient mapping in the OPERATION DESERT SHIELD area. The TerraBase computer program used by troop units for terrain data storage and manipulation was updated by the U.S. Military Academy and USAETL with a multispectral imaging routine to exploit multispectral imagery. Thirty-three Landsat scenes were obtained for selective transformation by the FSO onto digital audio tapes.

Images of the desert provided an additional challenge. Little was published on the interpretation of aerial imagery of desert terrain. Fortunately, USAETL had an ongoing research project in image analysis which had a desert test site providing continuous data about a desert environment (Jornada, New Mexico -- a joint effort with the U S Geological Survey) and also had produced a draft report titled Remote Sensing Field Guide, Desert. This draft document became an instant "best seller" with the terrain analysis community. It was provided to the USMC which hurried the draft study into production as an operational handbook under the auspices of the Commanding General, Marine Corps Combat Development Command, Quantico, Va. After an initial August 1990 press run of 4,000 copies, it has undergone revision and been reproduced again with a run of 10,000 copies. This guide describes and explains the significance of various desert landform patterns. The heart of the guide is a series of desert land-surface classification sheets. These classifications are divided into depositional patterns and transported materials, erosion patterns and residual materials for both wind and water, and special and minor features. Each of these patterns is discussed in a single sheet summary statement that describes the pattern, tells how it is formed, and provides a description of its military and engineering uses. The "uses" section contains information such as grain size distribution, chemical analysis of samples taken in the field and how the pattern will affect various operations. An accompanying pattern indicator sheet contains either ground, aerial or satellite images of the pattern, the location of the image in the world and the climate of that region. Terrain analysts having access to Landsat or SPOT imagery could go over the scene they have, compare it to scenes in the guide, and when similar patterns are identified, look them up and learn how the pattern observed will affect various aspects of planned operations.

This USAETL-produced guide, used in conjunction with relatively current satellite imagery as discussed above, is providing DESERT SHIELD terrain analysts with a windfall of information which directly supports the information needs of field commanders. Computer systems such as MICROFIX and FAISS (FORSCOM Automated Intelligence Support System) -- two Forces Command initiatives that support terrain data processing in topographic units -- the Digital Topographic Support System Prototype (DTSS-P) in topographic units, and GRID-based lap-top computers with terrain data processing software and data bases have revolutionized the way the Army handles terrain data analysis and presentation. The analyst, working within the computer framework, is able to view images, compare information derived from those images

with data base information in computer memory, evaluate the significance of the new data and produce a computer generated final product in orders of magnitude less time than had heretofore been possible. These systems were supplemented by ERDAS image processing systems specifically oriented toward the exploitation of multispectral information. ERDAS systems which had been under R&D evaluation in USAETL and user evaluation at the TRADOC Army Space Institute were procured and provided to the 30th Engineer Battalion (Topographic) to enhance the battalion's image processing capability.

To support this fielded terrain analysis computer capability, the FSO found itself deeply involved in converting digital data from DMA-provided wholesale distribution media (9-track digital tapes) into retail media -- digital floppy disks, digital audio tape and compact disks-read only memory (CD-ROM). In the initial weeks of OPERATION DESERT SHIELD, over 12,300 digital floppy disks of terrain elevation data (DTED) were prepared and provided to DESERT SHIELD units. Later, hard copy terrain analysis products were converted to digital files and provided to DESERT SHIELD units in formats and media compatible with their computer systems.

"The compatibility issue -- many different computer systems using many different geographic information systems (GIS) with several media requirements -- quickly became one of the "long poles in the tent."

There are four issues of compatibility for standard terrain analysis data bases, assuming the data qualities and data base contents are compatible.

First is the issue of media compatibility with the device used to read the data. The medium on which the data are distributed, such as 9-track tape, floppy diskette or CD-ROM, must match the hardware input peripheral, such as 9-track tape drive, floppy disk drive or compact disk reader.

Second, the physical format must be compatible -- how the files are stored and addressed on the medium so that it can be read by the systems device software. For example, if the data are produced on a DOS-formatted diskette, the system using the data must be able to read a DOS-formatted diskette.

Third, the logical format must be compatible -- how the data records are structured so that the GIS can read and incorporate them. For example, if the data are structured in a specific GIS format (such as ARC/INFO or ADDWAMS) or a product-specific format (such as DTED or Interim Terrain Data), the system using the data must have the applications software to read in this data content format.

Fourth, there must be attribute compatibility. For example, if the data uses the DMA-Feature File or some project-specific set of feature descriptors, then the

GIS using the data needs to understand the same feature definitions.

In some cases, data conversion involves just one type of format conversion, but in other cases, all types of conversion must be accomplished. It is not a trivial task. In the long term, when standards are adopted across the board for GIS data, this will not be such a key issue. But in the near term, the military's digital data holdings, as well as the systems that read in and use the data, are in a transitional state; and data compatibility is still a critical concern.

USAETL is involved in major GIS transformation efforts in support of DESERT SHIELD -- reformatting terrain analysis data bases and DTED, and the transformation of digital imagery for use in the field. Also, efforts have been escalated to ensure the rapid development of data import routines which will allow fieldable systems to use the available data."

Elizabeth Porter, TECH-TRAN, Vol 15, #4, Fall 90

Having addressed the issues of data availability, at least as far as satellite data is concerned, and terrain data extraction and manipulation, the new computer systems and all they have caused us to do, we are left with the problem of reproducing that information in formats which the end-users can understand. In-theater topographic support units have military standard printing equipment. It became quickly apparent that the local reproduction of black and white and color maps and photo-maps was desirable. The equipment on hand could handle the maps and black and white photo-maps, but was not able to achieve effective reproduction of the color photo maps. The Defense Mapping School developed procedures whereby local reproduction could be made. Unfortunately, presses are not cost effective in reproducing small-production quantities. To provide a cost effective, small-reproduction run for topographic products, an off-the-shelf copier was procured and sent to the field. This system is capable of satisfying small-quantity demands for operational planning products and color photo-maps. Work is underway to permit the reproduction of Landsat color composites directly from digital data, thus reducing the time for production of products from computers in digital form.

In OPERATION DESERT SHIELD, space-age technology and a whole lot more have gone to the field. The "Topographic Revolution" is being played out in the sands of the Middle East, supporting our forces in ways not even dreamed of in World War II, and only hoped for in Vietnam. Can the new technologies make a difference? Only time will tell. However, we are certain that they have had a massive impact on the topographic soldier and his support in the rear area. That soldier is more productive than ever, providing commanders and their staff officers with terrain data and tactical decision aids made from that data which decidedly effect the conduct of war planning. We in the Army topographic community are proud to be associated with the changes which have lead to that productivity gain.