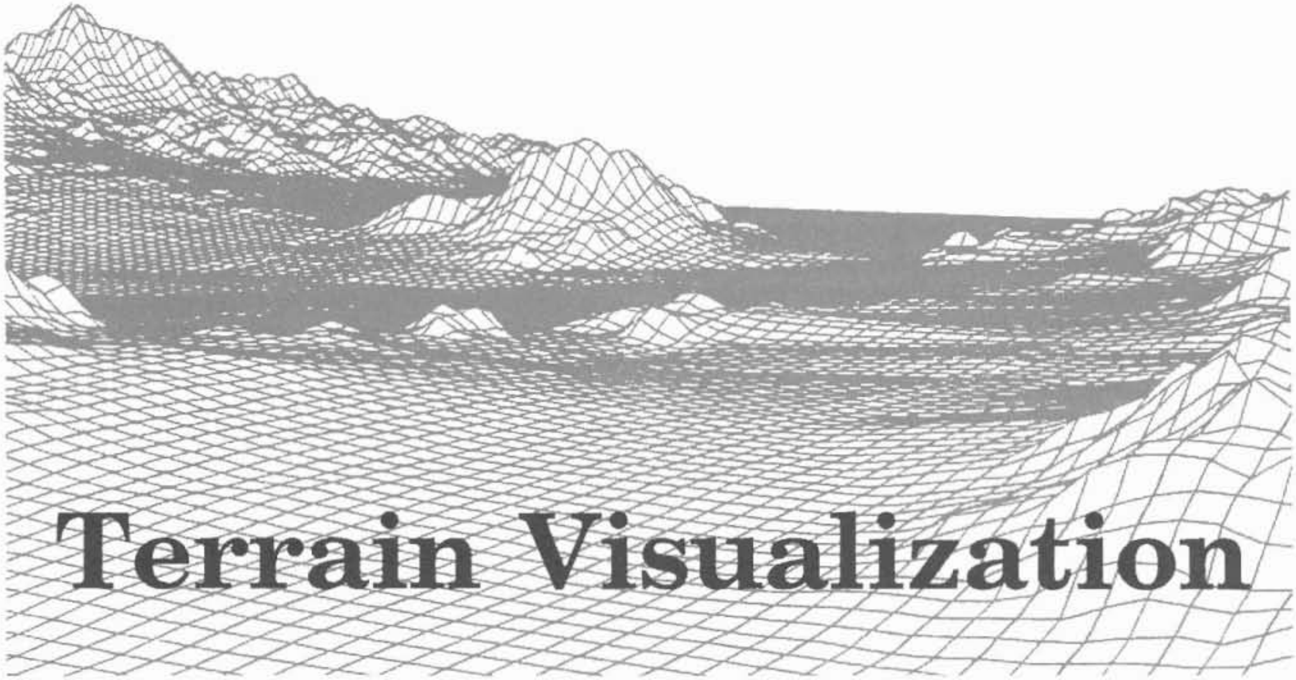


Terrain Visualization

By Captain Joe DeKeyrel

I have been reading science fiction since I was ten years old. I grew up with visions of soldiers wrapped in futuristic equipment to protect and inform them, slim formations with brilliant leaders who grasped every nuance of the battle before them. The premise of such leadership is that the leaders could "see" their entire area of interest, including friendly and enemy units, as well as terrain. The terrain piece belongs to the engineer.

As I was growing up, these images were suitably vague, with lots of flash and smoke but not much technical substance. As time passed and I continued to follow the spiraling technology devoted to the military, many of the old, vague visions of the future gained technical focus. Then, as the System Automation Support Officer for the Directorate of Combat Developments, U.S. Army Engineer School, I was tasked to bring some of these visions of the future into clearer focus.

The Vision

What I envision as an "ideal" terrain visualization system would allow—

- Input of Defense Mapping Agency (DMA) maps (as paper or ARC Digitized Raster Graphics (ADRG)), civilian "gas station" maps, satellite or aerial photography, and reconnaissance data.
- Rapid field updates of this data base and production of paper maps, raster graphics, and vectorized information.

Ideally, this system would smoothly and transparently operate with other systems to provide accurate, updated terrain data based on weather, traffic, and weapons effects. For example, soil trafficability would be affected by rain, large tracked formations moving over it, and loss of vegetation due to napalm or other weapons. The engineer terrain data base should be the common backdrop for all other visualization systems in use (such as intelligence, command and control, and mission planning and rehearsal). The complete system should consist of a large storage system (100+ Gigabytes), at least three workstations for scanning and vectorizing terrain data, a sheet-fed scanner, and a pair of printers for producing output. The software should take almost anything as source data and provide paper, raster and vector output with only minimal operator intervention.

Achieving the Vision

Almost all of the component pieces already exist for this ideal system. Using existing technology, Army engineers can provide a bewildering array of terrain-visualization products:

- Three-dimensional fly-throughs
- Overlays depicting go/no-go terrain
- Weapons line-of-sight displays
- Trafficability predictions based on vehicular movements
- Fog-coverage predictions from weather data

The only real shortfall is a fully automated way of generating the vectorized data base from raster sources.

There are dangers in building such a system. First, "techies" like myself tend to think that more information and better technology is *always* better.

Photo by Jim Anderson

MSG Ron Heupel uses a digital map scanner to prepare a paper map for a digital command and control background.

Obviously, this is a gross over-simplification. Having more of the type of data you need, logically presented and correlated, does help; but there are limits to what one person (the commander) can accept at one time. The second danger is that the system can grow into a technological showplace with capabilities that commanders may not need or want. To avoid these pitfalls, it is helpful to have input from the end users in the form of initial goals, as well as ongoing interaction throughout a project. We have assembled a system called the Rapid Army Combat Mapping Set (RACOMS) to experiment with mapping technologies to avoid these pitfalls.

Experiments

The Engineer School's involvement in terrain-visualization experiments began with the Louisiana Maneuvers (LAM). Our piece of the LAM experiment was to provide commanders with a common digital picture of the battlefield. Building on our LAM experiences, the U.S. Army, Europe (USAEUR) commander developed his vision and requirements for terrain visualization for his command. His requirements were broken into four stages for testing at a later date:

- Scan, update, and print paper maps
- Export updated map information as a raster background for vehicular command and control systems
- Vectorize updated information to provide terrain files for simulations systems (for example, the Urban Combat Computer-Assisted Training Systems (UCCATS)
- Accomplish these tasks/transformations for any location in the European Command area of responsibility within 120 hours

Even before the Engineer School became involved in experimenting with the Atlantic Resolve and USAEUR's goals, it wanted to test new hardware and software to support terrain visualization. To that end, the school purchased a Sun-compatible workstation as a test-bed system for exploring advanced cartographic and topographic analysis tools. The school also acquired a large-format color scanner that can scan an entire map sheet at once. ARCInfo, a geographical information system (GIS) and ERDAS, an image-processing package, were also installed.

The initial configuration allowed the school to scan an entire map sheet and perform any of the following functions:

- Print it in full color
- Save it into several standard data types
- Revise it by hand using a bitmap editor
- Print it at different scales
- "Stitch" several sheets together to provide a "seamless" map area

Any of these actions could be performed beginning with a set of ADRG data instead of paper.

The first practical application of the set was the creation of a special map for a National Guard unit whose assembly area is located in the corner of four standard map sheets. To create one special map, the four paper maps were scanned then registered with their latitude and longitude. Finally, the software warped the four sheets together. Once this was done, any subarea of the map could be retrieved. After selecting the area, the special map could be printed in color and as color separations for high-volume process printing.

ARCInfo allows any kind of data to be assigned to any location. The data could be an elevation, a slope, a vegetation type, an image, a sound clip, or anything that can be "contained" on the computer. Geographic locations are stored for points, linear features, and polygons, and data may be assigned to any of these features. After the data base is built, it may be queried in various ways. For example, after a road network has been entered into the data base, a movement-control officer could query the system for a route between two points that is hard-surfaced, has at least a 4-meter lane width, and crosses no bridges less than military load class (MLC) 70. After entering the query, the computer would show the routes between the two points that meet the criteria as highlighted lines. The Army could avoid the pitfalls of multiple standards and redundant data by drawing applications from the same data base. Some of these applications are route planning, terrain analysis, observation and fields of fire, and situational templating.

ERDAS can generate a very sophisticated map using land satellite (LANDSAT), Systeme Probatoire d'Observation de la Terre (SPOT) satellite imagery, or aerial photography. The process involves first rectifying and geo-referencing the image; then, using locations of known features (such as a hard-surfaced road, a lake, or a stand of deciduous trees) the software can classify the entire image by its "colors." Grid-lines, marginal information, and other map data can be added to produce a complete map product.

RACOMS Components

Sun SPARC compatible, manufactured by Axil

4 50MHz, TI Super SPARC processors

64 MB of DRAM

1 GB and 9 GB hard drives

19-inch color display

36-inch by 24-inch, 400 dots per inch, drum scanner

Solaris 2.3 Operating System with Motif 1.4 as the Windows manager

ARCInfo 7.1

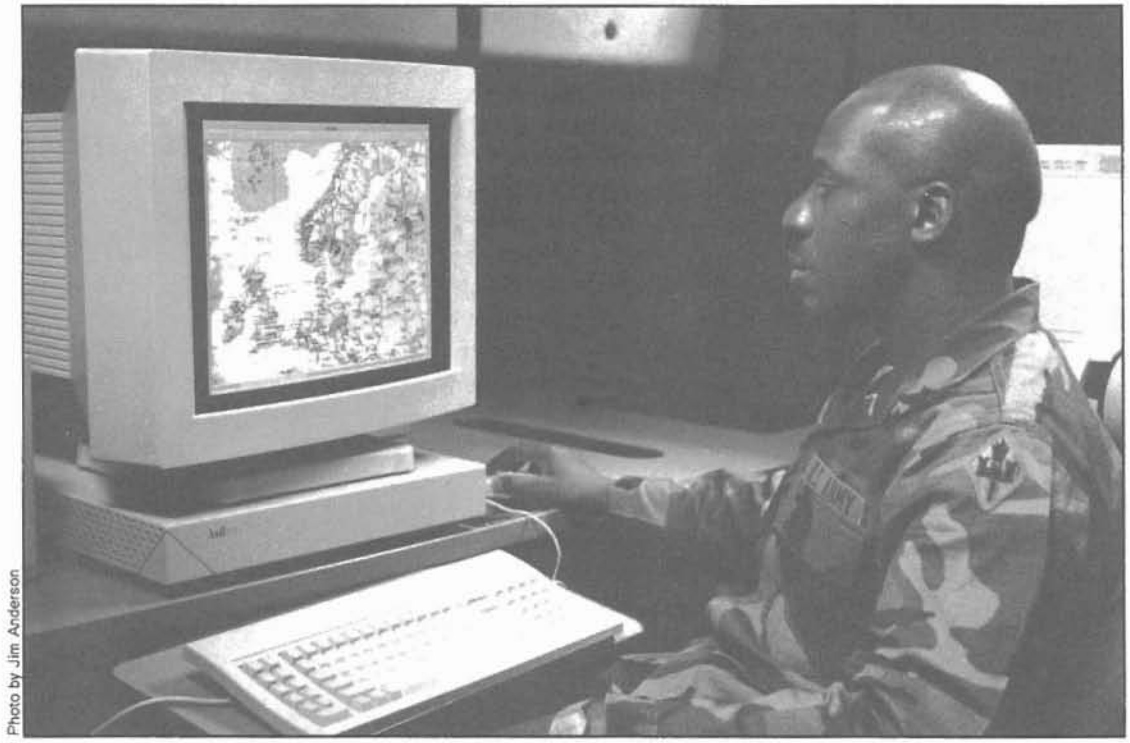
ERDAS Imagine 8.1

Various tape drives

Read/write CD

RACOMS Testing. Pieces of the RACOMS were tested at the Armor School and the Northern Lights exercise in April and June 1994. The entire RACOMS with full capability was assembled and tested in September at Fort Leonard Wood before it was sent to Germany to support Operation Atlantic Resolve. The first Atlantic Resolve test project was easy:

- Create a raster backdrop. A wealth of information can be stored in a vector data base, but we are accustomed to reading raster maps. Therefore, it is important to provide a "map" to overlay the vectors to provide orientation to the ground. The raster backdrop is created by importing files into ARCInfo that are in a tagged image file format. Once they are in ARCInfo, the files are registered (tied to specific locations on the ground) and rectified (changed from geographic coordinates to Universal Transverse Mercator coordinates). Then, any number of raster images can be merged to form a seamless raster backdrop.
- Create vector "coverages" showing such features as road networks, soil type, and vegetation. These vector layers make up the quantitative portion of the data base. Layers can be input from a digitizing tablet or created in a semiautomated way by scanning and machine-vectorizing line drawings of the features. For the Fort Leonard Wood area, these layers were digitized from the tactical terrain analysis data base (TTADB). The individual TTADBs were scanned, then vectorized using the ARCScan package. ARCScan allowed the school to vectorize a full 1:50,000 map sheet road network in about 30 minutes, as opposed to two to three hours to do it by hand. After the individual sections of a layer were created, they were stitched together to create continuous features (such as unbroken roads and rivers).
- Enter reconnaissance points from the tactical reconnaissance tool (TRT). The final task before going to Germany was to successfully import data points from the TRT, which uses a global positioning system (GPS) receiver coupled with a small computer to store locations and descriptions for points, routes, and polygons that can be coded in the field. A newer version will be linked to a stock-mounted, laser range-finder with an electronic compass. It will allow taking points from up to 2 kilometers away, a significant improvement for the soldier taking the data. The software that comes with the TRT allows a simple, 5-minute data conversion that results in a geo-referenced layer of data in ARCInfo format that can be overlaid on the existing data base with no further effort. A cellular modem allows information to be uploaded from the reconnaissance site.



SFC Braley McCutchen looks at an overview of an area of operation in an early phase of a field exercise.

Once the data base has been completed, it can be draped over elevation data taken from digital topographic elevation data so the entire terrain picture can be seen. The Korean data base will be demonstrated at the ENFORCE XXI Conference.

Louisiana Maneuvers Experiments. During the month in Germany, Engineer School personnel demonstrated the RACOMS to the Chief of Staff of the Army and the USAEUR commander, as well as to delegations from the German and French armies. However, most of the time was spent preparing products for Operation Atlantic Resolve, which took place on an artificial island called "Atlantis." Some of more than 400 projects completed during the exercise follow:

- Changed scale from 1:250,000 to 1:50,000 for several Atlantis map sections to provide special operations forces with usable products for their reconnoiters.
- Relocated an airport and created a fake road network to produce deception maps. The real airport was a reconnaissance target.
- Updated the road network for a city on an Atlantis map and added a bridge, using ground and satellite reconnaissance data as sources.
- Made several special maps from the Atlantis area, using both ADRG and paper maps as sources.
- Exported updated maps to ADRG format for use in command and control systems.

Summary

The Engineer School continues to improve the RACOMS. We are working to convert the ARCInfo vector files into JANUS and UCATTS terrain files, to facilitate simulations of specific courses of action on any terrain. The current setup is a one-of-a-kind test-bed system, although some of its capabilities are replicated in the field. USAEUR has procured several Sun systems, with slightly different configurations, and roughly equivalent setups exist at the Topographic Engineering Center and Waterways Experimentation Station. RACOMS functions will be fielded to the rest of the Army in a two-phased approach. This summer, all corps and divisions should receive their Digital Topographic Support System/Multispectral Image Processor (DTSS/MSIP) systems, which include the workstation, ERDAS software, and an output device. By late spring 1996, the "plus" upgrade to the DTSS/MSIP should be fielded, which adds ARCInfo and a scanner. So perhaps, in a small way, I have furthered the vision I had as a young boy—of "perfectly" informed leaders—by exploring one method of visualizing the terrain on the way to complete battlefield visualization.

Captain DeKeyrel was the System Automation Support Officer for the Directorate of Combat Developments before becoming the system engineer for a contractor at the National Training Center. Previous assignments include Platoon Leader, B Company, 44th Engineers (C)(H); and Commander, 902d Engineer Company (AFB). He holds a bachelor of science degree in mathematics from Virginia Military Institute.