Searching for Undergrounds with a High-Tech Toolkit

By Michael Klumb

Discovering the location of adversarial underground facilities is a difficult task. Being underground, most of the significant features are not visible in standard panchromatic imagery. To probe alternative signatures, NGA uses innovative technologies from academia, government labs and the commercial sector.

Classifying Urban Terrain

Historically, most underground facilities of interest have been located in rural areas. U.S. military forces, however, are increasingly involved in military operations in urban terrain, as adversarial forces move to the cities and underground to take advantage of the clutter an urban environment provides.

To be successful in the search for underground facilities in urban areas, analysts employ a multiplicity of innovative methodologies. One method to reduce urban clutter and consolidate a plethora of objects into a limited number of categories is to classify the land in accordance with its physical properties. The physical qualities of urban artifacts—streets, lots and buildings—form distinctive patterns when mapped.

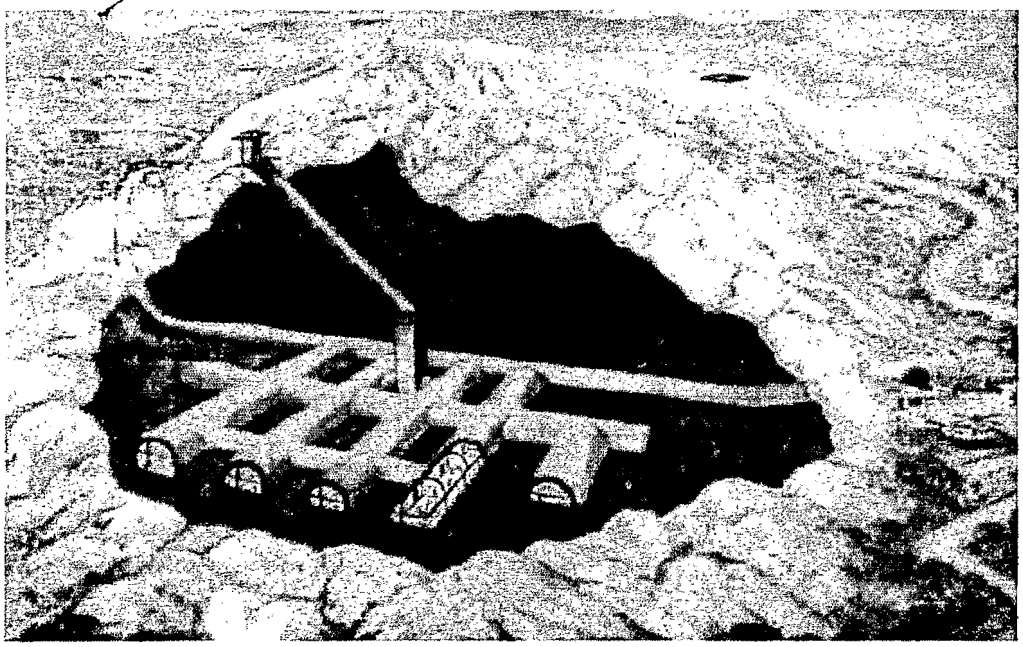
The Advanced Research Labs at Pennsylvania State University are involved in delimiting "urban terrain zones" (UTZs)—image-based products that classify the varying types of urban environments. Data contained in UTZs includes building dimensions, construction types, proximity and street patterns. This type of information, combined with other geospatial data, is the foundation for performing numerous types of analysis including site selection, network analysis and movement, and obstacle modeling. In addition to supporting the search for undergrounds, these analyses can support military operations, humanitarian aid, peacekeeping and non-combatant evacuation operations.

NGA has used UTZs as a major input to Orion, a high-performance spatial event-modeling framework. Upon extracting a model, Orion creates a forecast, based on features of interest defined by the user. Since all input data layers are georeferenced, the resulting forecast guides analysts to areas most likely to contain the features of interest, such as underground facilities.

Distinguishing Recurring Features

One of the NGA's longest-running partnerships is with Los Alamos National Laboratory, which has developed an application called Genetic Imagery Exploitation (GENIE) to find multiple occurrences of objects in an image. The premise of GENIE is to test scores of trial solutions and, as in genetics-based evolution, combine elements of the best or "fittest" ones to form new solutions. The solutions in this case are chains of image-processing steps to find a particular feature. A major advantage to this approach is that the physics describing the appearance of the selected feature does not have to be understood. The user just has to identify a few examples of the feature, and GENIE evolves a solution to find similar features.

NGA has used GENIE successfully to find areas of interest in multispectral imagery and conducted evaluations of GENIE as a general feature-extraction tool. Some of Los Alamos' new tools are directed



To defeat underground and deeply buried targets, NGA is collaborating with government, industry and academia in the search for creative applications of technology.

toward shape recognition, which would complement GENIE nicely.

Borrowing Techniques from Medicine

The Center for Subsurface Sensing and Imaging Systems (CenSSIS) is an engineering research center funded by the National Science Foundation. Established in 2000, CenSSIS is a collection of academic, industry and government partners. The vision of CenSSIS is to use similar techniques to solve diverse problems. Fields of interest include subcellular biology, medicine, underwater exploration and underground diagnosis. CenSSIS' Web site can be found at <http://www.censsis.neu.edu>.

NGA is leveraging CenSSIS' expertise in:

- image registration and geo-location,
- four-dimensional sensor fusion,
- object recognition,
- multispectral and hyperspectral image classification,
- distributed large-image data management, and
- understanding quantitative change.

NGA provided CenSSIS a large collection of commercial imagery data. Initial work focused on image registration, classification and data management. The foundation of the image registration work was based on algorithms developed by the medical community for registering retinal images.

CenSSIS provides access to top-quality personnel with applicable expertise. It is hard to beat the return on investment that this relationship provides NGA.

Using Radar Data

The use of radar data to discover features about the Earth's surface has many applications that make collaboration fruitful. NGA has been working with Vexcel Corp., which has developed a technique that can be used to detect underground construction where the ground has subsided. Vexcel used commercial Radarsat data to determine where the ground had subsided after construction of a subway line in London.

The involvement with groups outside of the Intelligence Community has brought NGA some long-lasting working relationships, cutting-edge scientific techniques, and the ability to solve some specific, but difficult, problems. Many of these groups, and others, offer technologies or concepts that can be used in solving intelligence problems. Supporting outside projects helps NGA stay at the front of emerging technologies and give its customers the best quality product possible.