DEVELOPING IGRS

ENGINEERS CREATE THE IRAQ GEOSPATIAL REFERENCE SYSTEM

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A critical component of national infrastructure is an accurate spatial reference system—a reliable network of permanent survey marks that have established horizontal coordinates and/or elevations that are referenced to a defined coordinate system. These survey control stations form the basis of a nation's Geographic Information System (GIS) databases, navigation systems, cadastral records, horizontal and vertical construction surveys, and resource management programs.

Even after the establishment of the global positioning system (GPS), control networks continue to be an essential component to the complicated science of positioning objects on, above, and below the Earth's surface. Surveys must be based on an accurate set of reference stations in order, for example, to lay out a bridge that successfully joins in the middle, or to position a runway on which planes conduct precision approaches.

The 175th Engineer Company (Topographic) (Airborne Corps) arrived in Baghdad in December 2004 to provide geospatial engineering support—including terrain analysis, geodetic survey, and map production—to Operation Iraqi Freedom. While preparing for its first mission in Iraq, the 175th Survey Section discovered that Iraq did not have an established spatial reference system; what data did exist was outdated.

The 175th took the leading role in developing a modern, GPS-based geodetic control network—the Iraqi Geospatial Reference System (IGRS). With technical guidance from the United States National Geodetic Survey (NGS), the 175th engineered IGRS in the likeness of the National Spatial Reference System (NSRS).

CORS Network

The foundation of IGRS is a series of GPS continuously operating reference stations (CORS), spread geographically throughout the country. The CORS network supports postprocessed differential GPS (DGPS) positioning in all regions of Iraq. Given a complete CORS network, a survey crew working to position critical infrastructure features could conduct its survey using GPS with meter-level accuracy. The crew could then download appropriate CORS data from other stations and use it to correct differentially the field data to obtain centimeter-level accuracies for the final product.

Each CORS site consists of a Trimble NetRS® dual-frequency GPS receiver with a permanently mounted antenna that logs position and time data 24 hours a day, 7 days a week. The stations are located at secure installations, and their data transmits through the Internet to a server in Iraq. Trimble's GPS Net® software controls the server, which stores and compresses the incoming data and then sends it via the Internet to NGS for analysis and publication. The dataset also is transferred to the public archives of the International GPS Service (IGS), a global network of geodetic reference GPS and Global Orbiting Navigation Satellite System (GLONASS) (a Russian satellite positioning constellation) reference stations

Photo by First Lieutenant Kenneth R. Joyce

A Soldier installs one of the CORS antennas that is part of the IGRS.

formed by the voluntary cooperation of many worldwide agencies.

NGS calculates the positions of the Iraqi CORS by processing data from each new station with data from a set of "hub" stations that are part of the existing global reference network. Geodesists produce the coordinates with Program for the Adjustment of GPS Ephemerides (PAGES) software that uses the method of "double differences" to remove clock errors in the GPS satellites and the ground stations. Once synchronized time is established, the precise locations of the satellites along their arcs of orbit may be calculated epoch by epoch. The positions of the Iraqi stations are then determined through triangulation by distance to the solved locations of the satellites.

However, GPS satellites circle the Earth's center of mass; therefore, their locations in space, and the resulting triangulation of points on the Earth, are determined in an X, Y, Z Cartesian coordinate system whose origin is located at the Earth's center of mass. Because site coordinates are determined in the reference frame of the GPS orbits, the mathematical Earth model for satellite orbit calculation is all-important, including the slow rate of drift of the Earth's tectonic plates and the features embedded on those plates, such as CORS antennas.

The NNR-NUVEL-1A model is perhaps the best-known model for predicting horizontal plate tectonic velocities for locations outside the United States, usually with an accuracy of a few millimeters per year for locations within stable plate interiors. This model, however, does not make allowance for deformable plate boundaries, such as the boundary between the Eurasian Plate and the Arabian Plate upon which Iraq lies. So the velocities of Iraqi CORS will need to be predicted periodically.

To supplement CORS, the 175th designed a nationwide high-accuracy reference network (HARN) of permanently monumented survey control stations. The goal is to achieve a station spacing of not more than 50 kilometers, which will equal a total network of 200 to 300 stations. Each HARN station consists of a stainless steel rod monument that is driven to refusal with a jackhammer. Stations are positioned with DGPS using as control the nearest active control station—either an established HARN running simultaneous GPS data collection or an Iraqi CORS.

All HARN positions are referenced to the International Terrestrial Reference Frame 00 (ITRF00), which is considered virtually identical to the World Geodetic System 1984 (WGS 84) (G1150) coordinate system.

Aside from various technical hurdles, developing the Iraqi HARN presents a formidable logistical operation. Field teams require constant resupply and protection in order to survive and complete their missions while spread throughout a desert that is extremely hostile. To supplement limited manpower, the 175th partnered with the 42d Engineer Regiment (Geographic), British Royal Engineers.

The American and British surveyors were split into autonomous teams that surveyed the first phase of the HARN, which covers the southern portion of Iraq. Each crew was led by a noncommissioned officer who was responsible for all aspects of his team's safety and completion of technical tasks for the survey. The IGRS Operations Cell synchronized the survey plans and coordinated the task force movements and logistics support. The CORS data are available on an interactive Web page. See *<http://www.ngs.noaa.gov/index.shtml>* and *<http://igscb.jpl.nasa.gov>*. Iraqi HARN data were published on compact disc and distributed throughout the coalition and to the Iraqi ministry of Water Resources, Surveying, and Mapping Center.

Global Outlook

Beyond Iraq's borders, many other developing nations require help with developing modern spatial reference systems. Through progressive outreach programs, NGS has provided equipment and expertise in Central and South America, the Caribbean, and Africa and Eastern Europe to nations that are establishing CORS and HARNs. These efforts have proven particularly effective in nations recovering from natural disasters. War-torn countries require the same geospatial reconstruction, and military engineering units are well-equipped to operate in these regions. By using IGRS as a model to create similar programs in nations like Afghanistan and Somalia, the Army could effectively package what NGS developed as a successful multination technical assistance program into a military reconstruction effort.

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