No-Cost GPS Observations Available Nationally

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High-accuracy GPS data is now available to surveyors at no cost in some parts of the country from a system operated by the federal government. In years to come, the data will be available across the country. The source of the data are Continuously Operating Reference Stations (CORS), a system that is the outgrowth of real-time differential GPS stations operated in support of marine and air navigation. It acts as a group of high-accuracy GPS receivers, storing observations 24 hours a day and making these observations available, at no cost, for online downloading. Because it will allow after-the- fact GPS data reduction, surveyors can benefit from the system by adding CORS data to data gathered during regular static or kinematic observing sessions. Currently, it is mostly composed of U.S. Coast Guard sites, but other proposed federal installations give the system the potential to grow to several hundred sites.

To gain a more thorough understanding of CORS, Professional Surveyor interviewed the person in charge of the program, Bill Strange, Chief Geodesist with the National Geodetic Survey in Silver Spring, Maryland. Strange said the ultimate goal of CORS is to provide 3D access to the National Spatial Reference System, accurate to within 2- 3 millimeters. The new geoid model being developed, GEOID96, will play a large part in obtaining required vertical accuracy but Strange feels it will be several years before observations will not have to be made on a local benchmark to achieve high vertical accuracy.

Expected to Achieve 1 Centimeter Accuracy

Currently, all of the CORS sites are accurate to within 3 centimeters horizontally and 5 centimeters vertically relative to each other but NGS expects to have this down to 1 centimeter horizontally and 2 centimeters vertically within six months. Plans include a new model of the ionosphere to allow single frequency receivers to achieve better accuracy. Strange mentioned that the geocenter of the International Terrestrial Reference Frame (ITRF) differs from NAD 83 by about two meters and that he feels the future coordinate system in the United States will ultimately be ITRF, not NAD 83. He stressed the importance of having all users on the most accurate coordinate system.

He mentioned that besides the differential positioning capability needed by surveyors, CORS data is also being used to control aircraft performing aerial photogrammetry. Another use has been found that might aid in weather forecasting. Because the positions of the CORS sites are known, meteorologists are able to use the data to estimate water content of the troposphere and use that information in the development of weather and climate models.

He said the CORS Mission includes assurance that all navigation and positioning in the United States is performed using a common coordinate system, providing users with data for after-the-fact positioning, permitting multi-use of CORS sites established by different groups, and promotion of CORS standards to facilitate multi- use. Strange said that until recently much of the data was obtained at a five-second sampling rate and placed in hourly files made available within 10 minutes after the hour. Other data was gathered at 30-second rates, available within a few hours of the beginning of the next day. Recent budget cutbacks have required NGS to go to a 30-second sampling rate for all stations. NGS is developing methods of interpolation that will allow 5-second data to be created from 30-second data. Currently, data for the past three weeks is available online. After that, data is archived on CD-ROMS that are available through normal distribution channels.

Fifty Coast Guard Stations

CORS is currently composed of the almost 50 U.S. Coast Guard stations being established to support marine navigation. These stations will line the coast of the Continental United States, Alaska, Hawaii, Puerto Rico and the Great Lakes. In addition, the U.S. Army Corps of Engineers (COE) is establishing another five stations up and down the Mississippi River to support dredging activities. More COE stations are planned for other inland waterways. The Federal Aviation Administration (FAA) has plans to establish 20 to 30 stations to support aircraft navigation, and is looking at establishing several hundred more at airports across the country. The National Aeronautic and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) have ten more stations that will be included. The Oceanic and Atmospheric Research component of NOAA has seven stations that are being used for meteorological research; the potential exists for the establishment of several hundred stations to support meteorological and climatological applications. NGS has three stations of its own that have been used to develop and implement the CORS program. Discussions are underway with the Texas Department of Transportation to include their ten stations.

NGS has established two different ways to gather the data. The first involves the use of a personal computer at the station. Files are automatically downloaded to the central data facility at NGS in Silver Spring on an hourly basis. Several days of observations are stored on the computer at the station. The advantage of this system is that the data can be retrieved from the remote computer in case there is a problem at the central data facility, The disadvantage is that the remote computers can, and do, malfunction, and personnel have to be available to deal with the inevitable malfunctions. The second method of data retrieval, the one employed to gather data from the Coast Guards sites, involves dedicated phone lines over which packets of data are sent to the central data facility. Data is sent real-time, and there are no computers or storage devices at the site. The disadvantage of this system is that if there is a problem at the central facility, all the data are lost. This data transmission is not to be confused with the primary mission of the Coast Guard stations, that being the radio transmission of real time differential corrections for navigation purposes. NGS is currently implementing a redundant system of receiving

computers at the central facility to ensure that data received from the Coast Guard sites will not be lost if one computer goes down.

Central Data Facility

The central data facility performs five primary functions: conversion of the data to a common format (RINEX), quality control of the data, determination and monitoring of station positions on a daily basis, creation of files for distribution, and data archiving. With a five second sampling rate, each station will produce about 5 megabytes of data per day in a compressed format. One hundred stations would therefore require handling half a gigabyte per day which, although not an unreasonable amount, requires the process to be almost completely automated. This amount of data is equal to almost one CD-ROM per day. Some users, notably the hand-held and GPS-in-the-plane photogrammetry segments, have requested a one-second sampling rate, but this would result in each station creating nearly 25 megabytes of data per day. Currently, the Coast Guard phone lines do not have sufficient capacity to handle the one-second data rates, and several groups are investigating the feasibility of interpolating the data.

When I related the experiences of Greenhorne & O'Mara (see sidebar), Strange told me NGS originally envisioned that surveyors would make fairly long observations using CORS to establish a base station, accurate to within a few centimeters, in or near the area where they were working and then use the base station to perform nearby radial surveys. Because the Gaithersburg CORS is located within the area where we were working, we were able to use it as the nearby reference station. Additionally, my primary goal was to create a system by which one man could operate independently. Unless the nearby reference station is located in a secure area, NGS' scheme would require a person to guard the equipment, thereby preventing the one-man concept.

Precise Orbital Information

Strange also discussed the use of precise orbital information obtained from either the Coast Guard or NGS. This information is available within one week after-the-fact and is importable by most GPS processing software. He said improved techniques have allowed the location of the satellites to within 10 centimeters of their true orbital position and that this precise orbital information will generally improve the accuracy of baselines over 100 kilometers in length. Strange said baselines several thousand kilometers in length are being measured to within one centimeter horizontally. Strange said that once the CORS sites are accurate to within a centimeter, if the data is unavailable from one CORS site, the user can wait 4-5 days for the precise orbits and then use any other CORS site to achieve equal accuracy. I inquired as to the validity of my single-vector approach (see sidebar) and he said that although the result is a single vector, if data is gathered at 15 second intervals and observations are made for fifteen minutes, the vector is really being computed from 60 separate sets of measurements to four or more satellites in view. The processing software will provide statistical information about all 60 sets and the user can easily identify any problems.