SECTION 1
Project Report

INTRODUCTION

Bremer County, Iowa, chose to embark on a county wide high accuracy geographical information system (GIS) survey. This project is designed in phases. The first phase consists of the GPS control survey and permanent 3D monumentation. Aerial Services Inc. of Cedar Falls, Iowa was selected to complete this Phase.

Thirty new control stations were added within the County. Thirty-four existing horizontal and/or vertical control stations set by others both inside and outside the County were included in the survey.

PROJECT REQUIREMENTS

The purpose of this survey was to establish a new horizontal control network using GPS survey equipment and techniques throughout Bremer County, Iowa. This network was to be referenced to the new Iowa High Accuracy Reference Network (HARN) of 1996. It was also the intent of the County to obtain elevations on each new monument that would be referenced to NAVD 1988. Because this control would be utilized to control the analytical triangulation of the aerial photography, the network geometry was ideal for a strong GPS survey. All new point locations for control were selected with the needs of both the analytical triangulation and GPS survey requirements in mind. In some instances, all of the needs could not be met due to physical obstructions or existing land features. In these instances, the needs of analytical triangulation were held primary and the GPS survey needs were satisfied second.

MONUMENTATION

To perpetuate the GPS control measurements, 30 new permanent monuments were set for the County. BERNTSEN driven aluminum rod monuments were selected for the permanent monuments. Each BERNTSEN station monument consisted of one three-foot smooth rod section and one three-foot top security fluted rod section with a stamped cap. These were driven to approximately 6" below the existing ground surface. For easy access and protection, a two foot long 5"diameter PVC pipe was placed over each rod monument along with a pre-cast aluminum access cover and backfilled with sand to facilitate drainage and to minimize frost movement.

The Bremer County Engineers Office handled the coordination of marking the various underground utility locations at each site.

RECONNAISSANCE

The most important criterion for GPS observations at any given location is a clear view to the sky. In terms of network design, it is desirable that the horizontal control be located near the perimeter of the project site. With this in mind, five existing HARN horizontal stations were recovered in and/or near Bremer County. All five were chosen to be included in the network. In addition, six points that were set previously by Aerial Services, Inc. for Butler County were recovered and used along the western edge of Bremer County.

Vertical control was selected to provide as much coverage as possible, both at the periphery and in the interior of the job area. Nine existing NGS, USGS and Third Order County benchmarks were recovered and included in this survey. All nine of the benchmarks were occupied directly. In addition, twelve points that were set previously by Aerial Services, Inc. for Black Hawk County were recovered and used along the southern edge of Bremer County. All points were occupied directly.

FIELD SURVEY

Three Ashtech Z-12 and one Ashtech Z-Surveyor dual frequency receivers were used in this survey. GPS observations began Tuesday morning September 21, 1999. GPS observations were made during daylight hours from Tuesday September 21, through Thursday afternoon September 23, 1999. One additional day of observation was done on Thursday November 11, 1999 to strengthen and improve the GPS network.

Rapid static GPS techniques were utilized to minimize the time and cost of the survey. The satellite "window", where at least six satellites were observable, was open for much of the day. Each measurement period during which all receivers observe satellites simultaneously lasted from 8 minutes to 30 minutes, depending on the distance being measured and the geometry of the satellite constellation.

DATA ADJUSTMENT

The total number of lines observed and processed was 384. Based on statistical indicators from the ASHTECH PRISM processing utility and analysis of loop closures, 123 lines were rejected and removed prior to data adjustment. These lines were either remeasured or considered unneeded for the adjustment. The final network is comprised of 64 stations and 143 baselines. All data adjustment was performed using the STARNET least squares adjustment software. An initial free adjustment was performed in NAD83 to check the overall quality of the GPS data and the nature of the control. The initial unconstrained (free) adjustment yielded baseline precisions which ranged from 1:60,000 to 1:1,500,000. Once the horizontal and vertical control was verified, subsequent adjustments were performed to arrive at the optimal solutions for each datum.

NAD83 (1996)

The initial free adjustment was performed holding point #85 fixed horizontally with the vertical adjustment disabled. Coordinate values on the other horizontal control stations were then checked against the published values. One at a time, each of the eleven remaining horizontal control points was added to the network and a new adjustment performed. After each adjustment a comparison of adjusted coordinates vs. published values was made. By holding all twelve of the existing horizontal control stations fixed, the precision of the "free" adjustment degraded very little.

Once the horizontal adjustment was completed, we locked the horizontal positions and concentrated on the vertical adjustment. The Geoid 96 Central zone was utilized to provide a model of the height of the Geoid. Adjustments were then performed locking on to the vertical control stations one at a time. Elevations on the benchmarks were then checked against the published values. Points 311 and 312 were not held for vertical.

A final adjustment of both horizontal and vertical was then performed. Because the control was so reliable, the final adjustment in NAD83 (1996) was very straightforward. All horizontal control was held fixed in x and y and all vertical control were held fixed in z with the exception of points 311 and 312. This fully constrained adjustment solved for scale and rotation. In the final adjusted network, 98% of the adjusted vectors have an estimated error of 1:100,000 or less. The results are well in excess of the first-order precision. The error ellipses for each point are listed in Section VI. The units of measure for the error ellipses are US survey feet.

CONCLUSION

All measured points will be usable for better than first-order control in horizontal position and with $\pm$ 0.1 ft. vertically for benchmark use.