

INTRODUCTION

Carroll County and The City of Carroll, Iowa, chose to embark on a high accuracy control survey.

One hundred fifteen new control stations were added within the Carroll County area. Nine existing Greene County GPS control points were recovered and tied into the GPS network. Twelve existing horizontal and vertical control stations set by others both inside and outside the project area were included in the survey.

PROJECT REQUIREMENTS

The purpose of this survey was to establish throughout the project area, a new horizontal control network using GPS survey equipment and techniques. This network is horizontally referenced to the Iowa High Accuracy Reference Network (HARN) of 1996. Vertically the network is referenced to the North American Vertical Datum of 1988 (NAVD88). 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, 72 new permanent monuments were set for Carroll County. Forty-three points set by The City of Carroll or others were also included in the survey. These points consisted of new rebar points, existing monuments and various section corner points dug up and marked by the City of Carroll Public Works office. 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 rebar points set consist of a 5/8" x 30" rebar with a red plastic photogrammetric survey cap set flush with the ground surface.

The Carroll County Engineer's Office handled the coordination of marking the various underground utility locations for each new 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 control stations were recovered in and/or near Carroll County. All five were chosen to be included in the network.

Vertical control was selected to provide as much coverage as possible, both at the periphery and in the interior of the project area. Seven existing NGS and USGS benchmarks were recovered and included in this survey. Five of the benchmarks were occupied directly and points 308 and 309 were TBM points set within 400ft of the existing bench disk monuments. A closed level loop was run, and the TBM points were occupied directly to facilitate GPS observations.

FIELD SURVEY

Two Ashtech Z-12 dual frequency GPS receivers along with two Ashtech ZXtreme dual frequency GPS receivers, all with Z-tracking capabilities, were used in this survey. GPS observations began Monday morning, May 21, 2001. GPS observations were made during daylight hours from Monday, May 21, through Friday, May 25, 2001.

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 60 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 360. Based on statistical indicators from the ASHTECH PRISM processing utility and analysis of loop closures, 27 lines were rejected and removed prior to data adjustment. These lines were either remeasured or were considered unneeded for the adjustment. The final network is comprised of 136 stations and 333 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 1:100,000 to 1:1,200,000. 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 #303 fixed horizontally with the vertical adjustment disabled. Coordinate values on the other four HARN control stations were then checked against the published values. One at a time, each of the four remaining HARN stations 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 the remaining four existing HARN stations fixed, along with holding the 9 Greene County GPS control stations fixed, the precision of the "free" adjustment degraded very little.

Once we were satisfied with the horizontal adjustment, 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. By careful analysis of multiple vertical adjustments it was determined that the published elevation for benchmark point #311 did not merit locking to for the final adjustment.

A final adjustment of both horizontal and vertical was then performed. All of the horizontal control points were held fixed in x and y and all vertical control were held fixed in z, except for point #311. This fully constrained adjustment solved for scale and rotation. In the final adjusted network, 92.0% of the total 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 IV. 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 ± 0.1 ft. vertically for benchmark use.

