Delaware County

Iowa

G.P.S. Survey

Control Network

2001

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INTRODUCTION

Delaware County, Iowa, has engaged Aerial Services, Inc. in Cedar Falls, Iowa, for the purpose of obtaining ortho-rectified imagery. As part of this project Aerial Services, Inc. was elected to carry out a high accuracy control survey.

Seventy-nine new control stations were added within the county area. Four existing Linn County GPS monuments were recovered and tied into the GPS network. Fourteen existing horizontal and vertical control stations set by others both inside and outside the project area were included in the survey. Two temporary rebar points were also set to aide in the analytics for the town of Edgewood, Iowa, on the northern border of Delaware County. Also, 45 temporary control points were set for two road projects, "D 47 East" and "X 31", west of the town of Hopkinton.

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 was horizontally referenced to the Iowa High Accuracy Reference Network (HARN) of 1996. Vertically the network was 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, 79 new permanent monuments were set for Delaware County. BERNTSEN driven aluminum rod monuments were selected for the permanent monuments. Each BERNTSEN station monument consists 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 temporary rebar points set for the road projects, along with the TBM points, consist of a 5/8" x 30" rebar with a red plastic cap set flush with the ground surface.

The Engineer's Office from Delaware County handled the coordination of marking the various underground utility locations for each new BERNTSEN 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 Delaware 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. Eight existing NGS benchmarks were recovered and included in this survey. Four of the benchmarks were occupied directly and points 302, 308, 310 and 316 were TBM points set within 400ft of the existing bench disks. A closed level loop was run, and the TBM points were occupied directly to facilitate GPS observations.

FIELD SURVEY

Four Ashtech Z-Xtreme dual frequency GPS receivers, all with Z-tracking capabilities, were used in this survey. GPS observations began Monday morning, November 12, 2001. GPS observations were made during daylight hours from Monday, November 12, through Friday, November 16, 2001. An additional day of observations was completed on Tuesday, November 27, 2001. Currently, the Sun is in its "peak" phase period of the approximate seven year cycle for its solar storm activity, according to N.O.A.A. Ionospheric disturbances (solar flares) regularly interrupted the GPS signal data during those observation periods. This did not prohibit GPS observations from occurring, however, it limited the length of vector baselines able to be measured in order to comply with project accuracy specifications. Aerial Services, Inc. was able to circumvent this problem by designing redundancy of measurements on different days for the same point, and some of the data was processed with a higher elevation mask at peak solar times to eliminate corrupt data from those satellites sending data from near the horizon. Also, occupation times were lengthened in order to collect more usable data. This helped to keep all vector residuals to a minimum and also helped to strengthen the overall network geometry.

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 308. Based on statistical indicators from the ASHTECH SOLUTIONS processing software and analysis of loop closures, 19 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 143 stations and 419 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 1:75,000 to 1:3,00,000. 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 #304 fixed horizontally with the vertical adjustment disabled. Coordinate values on the other 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 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 99 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 elevations for the benchmark points 301, 305, 310 and Linn County monuments #9A (#303), #9 (2001-73), #7A (#305) and #6 (2001-77) did not merit locking to for the final adjustment. The elevations for those four points included in this survey report are therefore newly GPS derived elevations only.

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 the afore mentioned points. This fully constrained adjustment solved for scale and rotation. In the final adjusted network, 98% of the adjusted County project vectors have an estimated error of 1:100,000 or less. The results are well in excess of the first-order precision.

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.