# Kossuth and Palo Alto Counties Iowa

# Countywide G.P.S. Survey Control Network

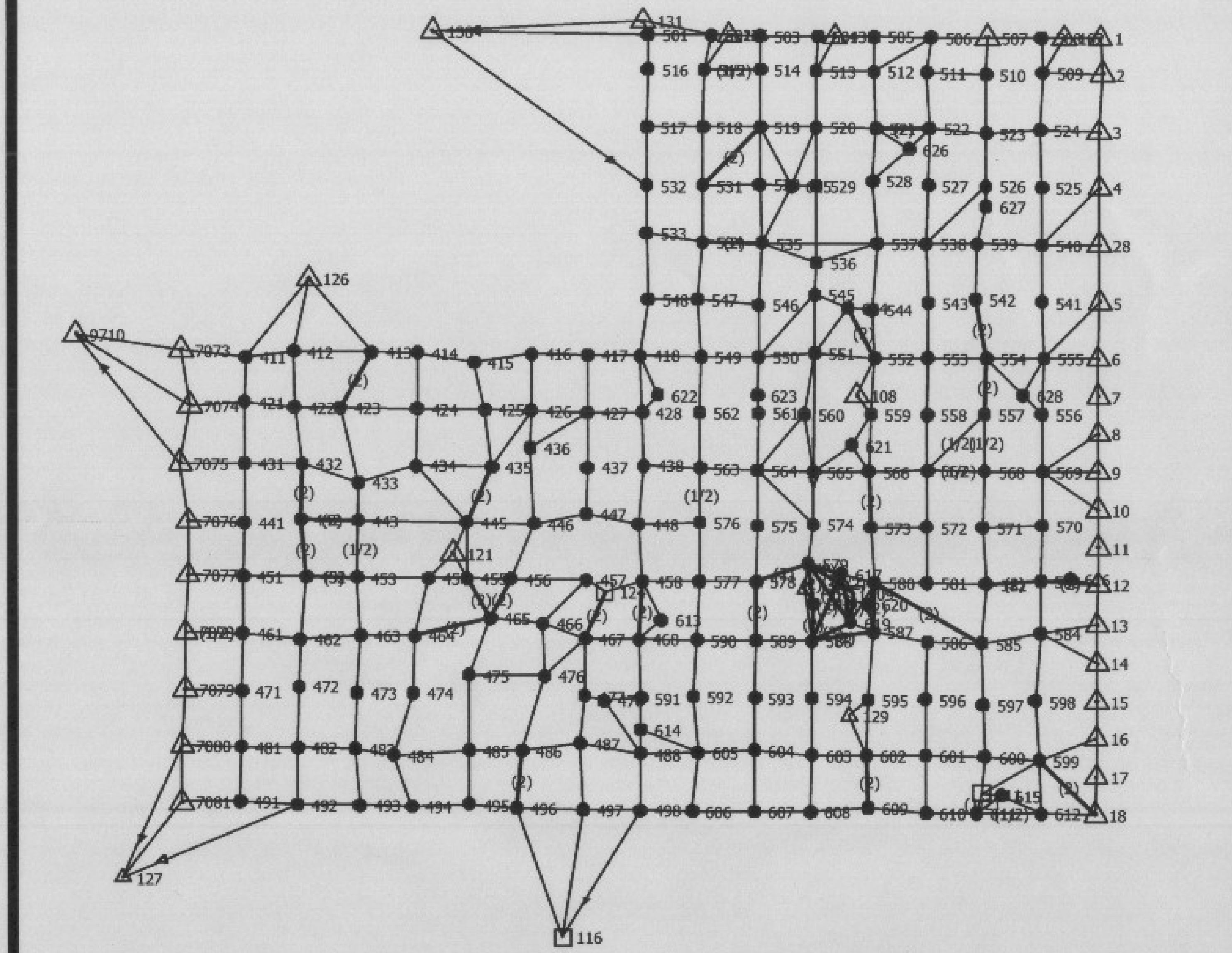
# 2005

Dan Corbin, Inc.
28 River Ridge Lane
Cedar Falls, IA 50613

DC Inc.

Cell: (319) 231-7047
Fax: (319) 266-3398
E-Mail: dcorbin@cfu.net

## Table of Contents



Field surveyor:
GGB & DC
Computer operator:
GGB
Reference:
Kossuth Co GPS Survey

Scale 1" to 41667 ft
0 75000 sft
US survey feet

0°00'00"

Plot Scale: 1" to 41667 ft
Printed on 1/13/2006, at 3:00:59 PM

Printed from Trimble Geomatics Office

Site: Not selected, System: US State Plane 1983
Zone: Iowa North 1401, Datum: NAD 1983 (Conus)

Project: Kossuth
USFeet Template

## INTRODUCTION

In 2005, Kossuth and Palo Alto Counties contracted with the team of DC Inc., GB Consulting and Kuehl and Payer Ltd. to complete a high accuracy GPS control survey in Kossuth and Palo Alto Counties, Iowa for the purpose of establishing a county-wide survey control system and for future use in a county-wide GIS system.

Seventy one (71) new control stations were added within Palo Alto County and one hundred twenty seven (127) new control stations were added within Kossuth County along with, nine (9) existing Clay County GPS control points, six (6) existing Winnebago County GPS control points and thirteen (13) Hancock County GPS control points were recovered and tied into the GPS network. An additional seventeen (17) control stations consisting of four (4) NGS first order benchmarks, were included in the network along with three (3) existing HARN positions and ten (10) HARN positions with first order vertical control A total of two hundred forty three (243) points were measured.

## PROJECT REQUIREMENTS

The purpose of this survey was to establish new state plane control throughout the project area, using a new horizontal and vertical control network with 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 for many different purposes, it was important that the network geometry be ideal for a strong GPS survey. All new point locations for control were selected with the needs of future multiple uses and GPS survey requirements in mind. In some instances, it was necessary to adjust locations because of physical obstructions or existing land features. In these instances, the network was constructed with the coverage of the county held as primary and the GPS survey needs satisfied secondly. Because both of these philosophies support good geometry the network structure was not compromised.

## MONUMENTATION

To perpetuate the GPS control measurements, 71 new permanent monuments were set by Palo Alto County for this survey and 127 new permanent monuments were set in Kossuth County by DC Inc. and Kuehl and Payer Ltd. 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 fastened to the top, all constructed of aluminum material. There is a permanent magnet mounted on the underside of the monument cap for future recovery with a magnetic locator. These monuments were driven to approximately 6" below the existing ground surface. For easy access and protection, a 24" 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. A steel fence post with a plastic sleeve was placed as a witness point at each new permanent monument position in Kossuth County.

In Kossuth County DC Inc. handled the creation of the One Call data with the County Engineer's office handling the One Call coordination for marking the various underground utility locations for each new permanent monument 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 and also throughout the project site if possible. With this in mind, existing HARN horizontal stations were recovered in and/or near Kossuth and Palo Alto Counties along with other control that has been adjusted to the HARN. All positions in and near the county 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.

## FIELD SURVEY

Six Trimble 24 channel dual frequency Geodetic GPS receivers with Everest multi-path mitigation and high performance low elevation satellite tracking were used in this survey. GPS observations were made during daylight and evening hours from Sunday, October 9, 2005, through Friday, October 14, 2005.

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 with only a short period of unacceptable coverage because of the number of satellites or bad geometry. Each measurement period during which all receivers observe satellites simultaneously lasted from 10 minutes to 130 minutes, depending on the distance being measured and the geometry of the satellite constellation.

## DATA ADJUSTMENT

A total number of 1177 vectors were observed and processed. Based on statistical indicators from the Trimble Geomatics Office processing software, there were 99 vectors flagged as outliers. After the re-measuring of these vectors and the removal of trivial vectors the final network is comprised of 243 stations and 484 baselines. All data adjustment was performed using the Trimble Geomatics Office 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 1:203,964 to 1:4,690,112 with the 3 mile baselines falling in the 1:500,000 range or better. 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 HARN point ALGOPORT (PID OP1149) fixed horizontally with the vertical adjustment disabled. Coordinate values on the other HARN control stations were then checked against the published values. The network fit the published HARN values within a few hundredths of a foot. Because all of the horizontal data fit so well, the HARN-referenced stations from other counties were 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 of the existing HARN stations fixed, and the control that was adjusted to the

HARN, the precision of the adjustment degraded very little as compared to the unconstrained adjustment.

Once we were satisfied with the horizontal adjustment, we locked the horizontal positions and concentrated on the vertical adjustment. The Geoid 03 Conus was utilized to provide a model of the height of the Geoid. Adjustments were then performed locking on to the orthometric vertical control stations one at a time beginning with R-1 (PID OP0130). Vertical control was added station by station with the elevations on the benchmarks being then checked against the published values. All vertical control fit extremely well.

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. This fully constrained adjustment solved for scale and rotation. In the final adjusted network, 100% of the adjusted vectors have an estimated error of x, y and z baseline precision between 1:165,811 to 1:2,872,428, with the 3 mile baselines again falling in the 1:500,000 range or better. All of the processed data and error factors were computed using a 95% confidence level factor.

On line user positioning (OPUS) service was utilized to calculate solutions at 4 sites within the network. The final adjusted 1996 HARN positions fit within a few hundredths of a foot horizontally and vertically to these solutions.

**CONCLUSION**

The results are well in excess of Order C class 1 (first-order precision) on short baselines (less than 3 miles) and between Order C class 1 and Order B on longer baselines (3 to 4 miles in length). On long baselines (over 6 miles) the precision is better than Order B. The control point locations are within ± 0.03 ft horizontal position and within ± 0.08 ft. vertically for benchmark use.

# Network Adjustment Report

***Project : Kossuth&PaloAlto***

| | | | |
|---|---|---|---|
| **User name** | Gary Brown | **Date & Time** | 2:43:55 PM 1/13/2006 |
| **Coordinate System** | US State Plane 1983/1996 HARN | **Zone** | Iowa North 1401 |
| **Project Datum** | NAD 1983 (Conus) | | |
| **Vertical Datum** | NAVD88 | **Geoid Model** | Geoid 03 (Conus) |
| **Coordinate Units** | US survey feet | | |
| **Distance Units** | US survey feet | | |
| **Height Units** | US survey feet | | |

# Adjustment Style Settings - 95% Confidence Limits

## Residual Tolerances

**To End Iterations** : 0.000033sft

**Final Convergence Cutoff** : 0.016404sft

## Covariance Display

**Horizontal**

**Propagated Linear Error [E]** : U.S.

**Constant Term [C]** : 0.00000000sft

**Scale on Linear Error [S]** : 1.96

**Three-Dimensional**

**Propagated Linear Error [E]** : U.S.

**Constant Term [C]** : 0.00000000sft

**Scale on Linear Error [S]** : 1.96

**Elevation Errors were used in the calculations.**

## Adjustment Controls

**Compute Correlations for Geoid** : True

**Horizontal and Vertical adjustment performed**

## Set-up Errors

**GPS**

**Error in Height of Antenna** : 0.015sft

**Centering Error** : 0.015sft

# Statistical Summary

**Successful Adjustment in 1 iteration(s)**

**Network Reference Factor** : 0.88
**Chi Square Test (α=95%)** : PASS
**Degrees of Freedom** : 843.00

## GPS Observation Statistics

**Reference Factor** : 0.88
**Redundancy Number (r)** : 808.08

## Geoid Model Statistics

**Reference Factor** : 1.00
**Redundancy Number (r)** : 34.92

## Weighting Strategies

## GPS Observations

**User-defined Scalar Applied to All Observations**

**Scalar** : 0.03

## Geoid Observations

**User-defined Scalar Applied to All Observations**

**Scalar** : 0.21