U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
NATIONAL GEODETIC SURVEY
GEODETIC SERVICES DIVISION
INSTRUMENTATION & METHODOLOGIES BRANCH

LOCAL TIE INFORMATION REPORT
NGS CORS SITE: CORBIN, VA

Kendall L. Fancher
Steven Breidenbach
Charles Geoghegan

Dates of Survey: February 03, 2012 - February 15, 2012
Date of Report: February, 2012

Contents

Introduction

The National Geodetic Survey's foundation CORS strategy includes conducting local tie surveys. Within NGS, these type surveys are the responsibility of the IERS Site Survey (ISS) program.

During February of 2012, the NGS ISS program conducted a local tie vector survey at a NGS CORS site located in Corbin, VA. This was a survey of opportunity as the associated GPS antenna had stopped working, requiring replacement. This presented an opportunity to directly tie the CORS antenna reference point (ARP) to a ground network of survey marks and refine field and data analysis procedures. No other space geodetic techniques are co-located at this site.

This report documents the instrumentation, procedures, data analysis, comparison to previous surveys, and local tie information results associated with this survey.

1. Site description

NGS CORS station CORB is located in the United States of America, in Virginia state at longitude W77° 22' and latitude N38° 12', near the village of Corbin at the NGS Training Center & Laboratory facility. A single CORS station is located at this site.

4 character ID	Domes#	Description	Site Name
CORB	49746S001	Concrete Pier with SECO-type antenna adapter	Corbin

Table 1 – NGS CORS site information can be found at http://www.ngs.noaa.gov/CORS/

2. Instrumentation

2.1. Tacheometers, EDMI, Theodolites

2.1.1. Description

Leica TDM5005 Electronic Tacheometer, S/Ns: 441698 and 441773.
Specifications:
Angular measurement uncertainty: ± 0.7"
Distance standard deviation of a single measurement: 1 mm + 2 ppm

2.1.2 Calibrations

Instruments calibrated by Leica Geosystem AG Heerbrugg, Switzerland.
Inspection date: 08/15/2008 / 08/20/2008
The instrument was found to be within factory specifications.

2.1.3 Auxiliary Equipment

Wild NL4 Collimator, S/N: 40145 pointing accuracy, 1: 200,000
Thermometer/hygrometer: Omega RH83, checked against thermistors maintained at the Instrumentation and Methodologies Branch (IMB) of NGS's Geodetic Services Division (GSD).
Barometer: Leitz AIR-HB-1L, S/N: 1L1890

2.2 GPS units

2.2.1 Receivers

For the first session on Day 37, four (4) Trimble R7 L1/L2+L2C 5700 chassis w/Maxwell-5 ASIC, P/N: 50157-00, S/Ns: 220375164, 220375172, 220390608 and 220390619 were used. For the second session beginning on Day 116, four (4) Trimble NetR5 GPS L1 C/A Code, L2C, L1/L2/L51 Full Cycle Carrier, GLONASS L1 C/A Code, L1 P Code, L2 P Code, L1/L2 Full Cycle Carrier with Maxwell™ Custom Survey GNSS Chip, P/N: 62800-00 , S/Ns: 0220390614, -19, -24 and -32 were used.

Specifications for Static GPS Surveying:
Horizontal +/- 5 mm + 0.5 ppm RMS
Vertical +/- 5 mm + 1 ppm RMS

2.2.2 Antennas

Four (4) TPSCR.G3, Topcon GPS/GLONASS/Galileo choke ring antenna, model CR-G3, P/N: 1-044301-01, S/Ns 383-1613, -1614, -1626 and -1628

2.2.3 Analysis software, mode of operation

Post-processing and adjustment were undertaken using NGS's beta version of Online Positioning User Service (OPUS) Projects interactive web page. At an actual new foundation CORS site, the CORS monument would not have a known position. Therefore, the ISS team treated CORBIN CORS ARP, as well as all other ground network marks, as unknowns. OPUS Projects selected surrounding CORS to be used.

2.3 Leveling

2.3.1 Leveling instruments

Leica DNA03 digital level, P/N: 723289, S/N: 332228.
Height measurement accuracy is +/-0.3 mm per km, double run.

2.3.2 Leveling rods

Single-piece Leica 2-meter invar rod, P/N: 563660 S/N: 30721

2.3.3 Checks carried out before measurements

Daily instrument collimation test procedures were undertaken on-site prior to data collection. Leveling rod bubbles were checked daily, prior to use.

2.4 Tripods

Wild Type II tall wooden tripods and a wooden observing stand were used. Target, reflector and instrument heights were measured by differential leveling at time of set up; centering achieved using a NL4 Collimator. Instrument/target heights and collimation were checked for any disparity before taking down tripods.

2.5 Forced centering devices

Wild GDF21 tribrachs were precisely collimated and secured over the network stations each day. The tribrach accommodates both the tacheometer and target/reflector.

2.6 Targets, reflectors

Five (5) Leica GPH1P precision reflectors were used as needed for tacheometer observations, acting as both target and reflector. For each reflector, the manufacturer-provided offset values of -34.4 mm were validated at the IMB facility prior to the survey.

3. Measurement Setup

3.1 Ground network

There is an extensive network of ground monuments located at the Corbin facility. For this survey, three existing monuments were recovered in good condition, which provided for strong geometrical design surrounding CORB and the two antenna calibration piers. The physical reference point for CORB is normally inaccessible. CORB ARP was observed both directly and indirectly this survey.

3.1.1 Listing

Network Station Name (2012)	Network Station Name (1995)	Network Station Name (1994)
BLDG 11	N/A	N/A
CORBIN QUAD CP	N/A	N/A
7550004	N/A	7550004
CORBIN N PIER ADAPTER	CORBIN N PIER ADAPTER	CORBIN N PIER AD
CORBIN S PIER ADAPTER	CORBIN S PIER ADAPTER	CORBIN S PIER AD
CORBIN CORS ARP	N/A	N/A
N/A	ASTRO EAST PIER	N/A
N/A	CORBIN QUAD 2	N/A
N/A	CORBIN QUAD 3	N/A
N/A	CORBIN QUAD 4	N/A
N/A	N/A	7550003
N/A	N/A	7550002

Table 2 - Listing of Network Stations

BLDG 11 (no PID) is stainless steel rod, inside of grease filled sleeve, inside of a protective PVC sleeve. The stainless steel rod associated with BLDG 11 is of an unknown depth. The grease-filled sleeve depth is unknown.

CORBIN QUAD CP (PID HV8189) is survey disk set in top of a round concrete post monument.

7550004 (PID HV7841) is a vertical control disk set in top center of a round concrete post monument.

3.1.2 Map of Network

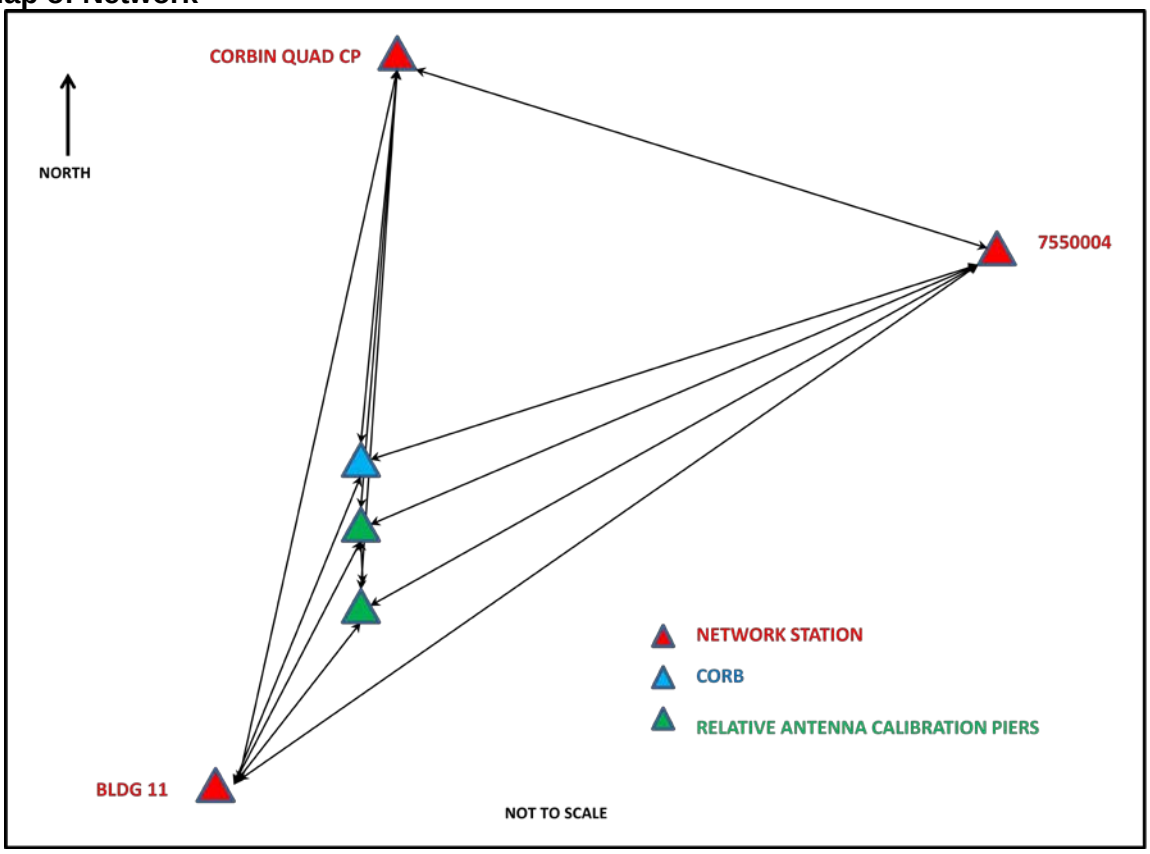


Figure 2 - Map of Network Stations

3.2 Representation of Technique Reference Points

3.2.1 VLBI/VLBA

This technique is not represented.

3.2.2 SLR (N/A)

This technique is not represented.

3.2.3 GPS

The GPS reference point is coincident with the ARP. The monument consists of a concrete pier designed by NGS's Process Action Team 20. The antenna mount is a standard tribrach adapter fastened directly to a metal plate, which was anchored into the concrete at the time of the pour. The non-functioning antenna was removed allowing a direct survey tie. Tacheometer measurements were taken both to and from this point. Position by indirect intersection observations was also determined for comparison sake when the new antenna was in place. Visit http://www.ngs.noaa.gov/CORS/ and Enter SiteID "CORB" for a current site log.

Figure 4 -CORB, view toward north-northeast.

3.2.4 DORIS (N/A)

This technique is not represented.

3.2.5 GLONASS (N/A)

This technique is not represented.

4. Observations

4.1 Conventional Survey

A complete list of unadjusted and adjusted tacheometer field observations consisting of directions, zenith distances, slope distances, and instrument and target heights are included in Attachment A. 3-D Adjustment Results (STAR*NET 3-D LST file).

4.2 Leveling

Leveling consisted of two loops that conformed to first-order, class I standards with the exception of appropriate ties to the National Spatial Reference System. The objective was to develop a network with height differences at the highest NGS standard. The primary loop ran from CORBIN QUAD CP to 7550004 to BLDG 11 to CORBIN S PIER ADAPTER and back on CORBIN QUAD CP. The secondary loop ran from CORBIN S PIER ADAPTER to CORBIN N PIER ADAPTER to CORBIN CORS ARP and back on CORBIN QUAD CP. See Attachment B. Abstract of Leveling Observations for leveled height differences.

4.3 GPS

Two sessions each were observed on four ground control marks; 7550004, BLDG 11, CORBIN CORS ARP and CORBIN QUAD CP. Information on vectors simultaneously processed to six CORS is not shown.

MARKS		ANTENNA	HEIGHT (m)	EPH TYPE	OBS (%)	FIXED (%)	RMS (m)	LAT (m)	LON (m)	HGT (m)
7554		TPSCR.G3 NONE	1.3475	precise	96.3	100.0	0.008	0.000	0.000	0.001
bl11		TPSCR.G3 NONE	1.4732	precise	98.8	100.0	0.008	0.000	0.000	0.001
cor2		TPSCR.G3 NONE	0.0000	precise	99.2	99.3	0.004	0.000	0.000	0.001
cqcp		TPSCR.G3 NONE	1.4253	precise	98.8	99.0	0.007	0.000	0.000	0.001
PREFERENCES:				**Best Available**	**≥80.0**	**≥80.0**	**≤0.025**	**≤0.020**	**≤0.020**	**≤0.040**

Table 1. Day 37: Solution quality indicators

MARKS		2012-02-06						2012-02-07																																			
		21		22		23		00		01		02		03		04		05		06		07		08		09		10		11		12		13		14		15		16		17	
7554		9	7	8	8	8	9	9	8	8	A	A	9	A	9	8	9	9	A	A	9	8	8	9	9	9	A	9	9	9	9	8	9	9	8	9	8	9	7	7	8	8	8
bl11		0	7	8	8	8	9	9	8	8	A	A	9	A	9	8	9	9	A	A	9	8	8	9	9	9	A	9	9	9	9	8	9	9	8	9	8	8	6	7	8	8	0
cor2		0	7	8	8	8	9	9	8	8	A	A	9	A	9	8	9	9	A	A	9	8	8	9	9	9	A	9	9	9	9	8	9	9	0	0	0	0	0	0	0	0	0
cqcp		8	7	8	8	8	9	9	8	8	A	A	9	A	9	8	9	9	A	A	9	8	8	9	9	9	A	9	9	9	9	8	9	9	8	9	8	9	7	7	8	8	8

Table 2. Day 37: Data availability in 30 minute cells

MARKS		ANTENNA	HEIGHT (m)	EPH TYPE	OBS (%)	FIXED (%)	RMS (m)	LAT (m)	LON (m)	HGT (m)
7554		TPSCR.G3 NONE	1.518	precise	96.4	98.7	0.014	0.000	0.000	0.001
bl11		TPSCR.G3 NONE	1.475	precise	98.2	100.0	0.014	0.000	0.000	0.001
cor2		ASH700936E NONE	0.000	precise	98.2	100.0	0.017	0.000	0.000	0.001
cqcp		TPSCR.G3 NONE	1.559	precise	97.4	100.0	0.014	0.000	0.000	0.001
PREFERENCES:				**Best Available**	**≥80.0**	**≥80.0**	**≤0.025**	**≤0.020**	**≤0.020**	**≤0.040**

Table 3. Day 116: Solution quality indicators

MARKS		2012-04-25																																															
		00				01				02				03				04				05				06				07				08				09				10				11			
7554		0	0	0	A	9	9	A	8	8	8	8	8	9	9	9	9	9	A	9	9	A	9	A	9	9	9	8	8	8	9	9	9	8	8	8	9	9	9	8	8	8	7	6	7	8	0	0	0
bl11		0	0	B	A	9	9	9	8	8	8	8	8	9	9	9	9	9	A	9	9	A	A	A	9	9	9	8	8	8	9	9	9	8	8	8	9	9	9	8	8	8	6	6	7	8	0	0	0
cor2		9	A	A	A	9	8	9	7	7	7	7	8	9	9	8	8	9	9	9	8	8	A	9	9	8	8	9	9	8	8	8	8	8	8	7	8	8	8	8	8	7	7	6	7	8	8	9	9
cqcp		0	0	B	A	9	9	A	8	8	8	8	8	9	9	9	9	9	A	9	9	A	A	A	9	9	9	8	8	8	9	9	9	8	8	8	9	9	9	8	8	8	7	6	7	8	0	0	0

Table 4. Day 116: Data availability in 15-minute cells

See Attachment C. Redundant GPS Vectors for precision.

4.4 General Comments

Data collection software GeoObs v1.04.02 was used for recording field measurements and for data quality checks.

CORBIN CORS ARP was surveyed both with and without a GNSS antenna installed. In a typical foundation CORS site survey, either situation could apply (but seldom both). Measuring directly to and from the antenna mount is inherently more accurate. This survey presented an opportunity to evaluate the indirect intersection method that would be required if a CORS site is operating normally. The position determined by this method compared at the sub-millimeter level of precision. See Table 5.

Differential leveling was conducted through all ground control stations. Additionally, leveling procedures were used to transfer height information to the top of the each of the GNSS antenna mounts (aka ARPs) of CORBIN CORS ARP, CORBIN N PIER ADAPTER and CORBIN S PIER ADAPTER. These leveled height differences were considered a standard to effectively check GPS-derived heights and trigonometric leveling observations between network stations for quality. Leveling to CORBIN CORS ARP was conducted conventionally with the antenna removed and also by "zeroing out" the level instrument with the antenna in place (see Figure 5). The two methods differed by 0.2 mm in height.

Figure 5 – "Zeroing out" the level instrument's reticle on the mounting surface of the antenna (aka ARP) is achieved by raising or lowering the instrument; coarsely by adjusting the tripod height, and then a finely with the instrument's footscrews. Independently leveling to both sides provides a clear target while eliminating any error due to any tilt or mis-level of the antenna.

Leveling procedures adhered to Federal Geodetic Control Subcommittee (FCGS) first-order, class I field specifications. However, because the site survey did not require heights referenced to a vertical datum, network geometry requirements for a tie to existent vertical control were waived. Translev v4.16 was used to facilitate the process of editing, formatting and checking of the digital leveling observation data, apply refraction corrections and create an abstract of observations.

5. Data Analysis and Results

5.1 Terrestrial Survey

5.1.1 Analysis software

Two least squares adjustments were conducted on the terrestrial survey data using commercially available software StarNet version no.7.1.0.5; a minimally constrained vertical adjustment and a minimally constrained 3-dimensional (3-D) adjustment. Results were reviewed for outliers in the survey observations and used to verify the accuracy of the survey.

The vertical adjustment, consisting of the leveled height differences between all network stations, CORB, CORBIN N PIER A, and CORBIN S PIER A, was conducted to establish height information for all network stations CORB, CORBIN N PIER A, and CORBIN S PIER A. See attachment D. for leveling data adjustment results.

The 3-D adjustment consisted of terrestrial observations of all network stations, CORB, CORBIN N PIER A, and CORBIN S PIER A. Assumed local coordinates (0m,0m,66.885m) for BLDG 11 with an assumed azimuth of 0^{O}, 0', 0" to CORBIN QUAD CP were used in the minimally constrained adjustment. See Attachment A. 3-D Adjustment Results (STAR*NET 3-D LST file) for results.

5.1.2 Topocentric coordinates and covariance

For topocentric coordinates and covariance information see Attachment E. AXIS Output Results File, section 2. INPUT SOLUTION.

5.1.3 Correlation matrix

For computed correlation matrix information, see Attachment F. SINEX File NGSCORB1202GA.SNX.

5.1.4 Reference temperature of radio telescope [for thermal expansion]

Not applicable

5.2 GPS Observations

5.2.1 Analysis Software

NGS's beta version of Online Positioning User's Service (OPUS) Projects was used to post-process and perform a least-squares 3-D adjustment of GPS data. See Attachment G. GPS Geocentric Coordinates and Covariances for the OPUS Projects output SINEX file.

OPUS Projects uses NGS's PAGE5 v1203.27 for post-processing. Default settings were used with two exceptions; 1) CORBIN CORS ARP was set as a hub and 2) the cutoff elevation for processing was lowered to 10^{o}. The remaining default settings resulted in the:

- use of IGS08.atx absolute antenna calibration file
- use of IGS orbits (+/- 2 cm)
- use of IGS08solution coordinate reference system with coordinates updated to date of observations using velocities
- use of default (modeled) meteorological values
- use of dual-frequency ionospheric correction
- time parameters solved in data reduction
- double-difference, ionosphere-free (IF) combination solution, where

$$IF = \{f_{21}/(f_{21} - f_{22})\}L_1 - \{f_1 f_2/(f_{21} - f_{22})\}L_2$$

- not all integer biases were determinable resulting in partial, fixed integer estimate of biases

Intended accuracy of vectors is 0.1 ppm plus 0.5 cm (A-order). All base lines were measured twice, once on each of two days. Redundant vectors were checked against each other to ensure accuracy was met. See Attachment C. Redundant GPS Vectors.

OPUS Projects uses the program GPSCOM v1203.15, a simple Helmert Blocking normal equation processor which combines multiple GPS data sets that have initially been processed by the program PAGES, to form and partially reduce normal equations eliminating numerous nuisance parameters which are not generally of interest in a large global adjustment. The normal equation elements for the global parameters, those to be passed on to a combined adjustment, are written by PAGES into a normal equation file which becomes the basic input data for the program GPSCOM. One or more of these files as well as its own output normal equation files can then be processed by GPSCOM to provide a combined adjustment of the global parameters. This program was written in FORTRAN. Predominantly ANSI standard FORTRAN, a few isolated routines query the operating system for time and date, user and system identification. These "system" routines are inherently non-portable but, should be easily modified or disabled. For more information, go to http://www.ngs.noaa.gov/GRD/GPS/DOC/gpscom/gpscom.html

5.2.2 Results

The GPS data was used exclusively for transformation from a topocentric to geocentric reference frame. Table 3. includes the adjusted IGS08(2012.076) geocentric coordinates for those network stations included in the GPS survey.

GPS STATION	X	Y	Z
7550004	1097071.2914	-4897222.5638	3923134.8720
BLDG 11	1097036.6837	-4897251.7279	3923108.7478
CORBIN CORS ARP	1097041.2148	-4897238.4279	3923126.2779
CORBIN QUAD CP	1097038.9281	-4897223.9994	3923141.9723

Table 3 – GPS-derived geocentric coordinates

The GPS data collected using survey-grade receivers, choke ring antennas, post-processed and adjusted with OPUS Projects shows a very high level of precision. Table 4 displays the inversed local coordinate values between geocentric coordinates computed by OPUS Projects and the coordinates for the same point that resulted from independent terrestrial observations.

COMMON STATIONS	dN	dE	dU
7550004	-0.0003	0.0003	0.0007
BLDG 11	0.0002	-0.0001	-0.0013
CORBIN CORS ARP	0.0002	-0.0001	0.0002
CORBIN QUAD CP	-0.0002	-0.0001	0.0003

Table 4 – OPUS Projects results compare very favorably to terrestrial observations (after aligning in AXIS)

5.3 Additional Parameters

Not applicable.

5.4 Transformation

The adjusted local topocentric coordinates for all stations were aligned to IGS08 (2012.076) in a transformation using AXIS software. Results can be found in Attachment E. AXIS Output Results File, section 3.

5.5 Description of SINEX generation

The SINEX file was directly generated by AXIS. For details, see Attachment E. AXIS Output Results File, section 5 USER INPUT SINEX INFORMATION. The following SINEX naming convention, adopted by GSA for local survey data, was also used for this survey.

XXXNNNNYYMMFV.SNX

Where:

XXX is a three-character organization designation
NNNN is a four-character site designation
YY is the year of the survey
MM is the month of the survey
F is the frame code (G for global, L for local)
V is the file version

See Attachment F. SINEX File NGSCORB1202GA.SNX.

5.6 Discussion of Results

A minimally constrained vertical adjustment of differential leveling data was run in anticipation of the 3-D adjustment of tacheometer observations. A GPS-derived orthometric height for BLDG 11was held fixed. Data from two leveling loops connected the bench mark to two network stations and the three GNSS antenna piers, CORBIN CORS ARP, CORBIN N PIER ADAPTER, and CORBIN S PIER ADAPTER.

- The residuals of the adjusted elevations were consistent among all six points.
- The sum squares of standard residuals is 1.397 with an error factor of 0.356.
- The Chi-square test at 5 % level exceeded the lower bound of 0.548. Upper bound is 1.454.

See Attachment D. Leveling Data Adjustment Results (CORB vertical.lst) for additional details.

NGS geoid/vertical deflection software showed no significant slope or deflection within the boundary of the project. Hence, the least-squares estimates of observed height differences were assumed valid for all necessary height applications, including calls for ellipsoid height differences.

A minimally constrained 3-D adjustment of tacheometer observations was run. The assumed local coordinates were minimally constrained at BLDG 11along with an azimuth line from this station to CORBIN QUAD CP. Also held minimally constrained were the adjusted leveled height differences for the two other network stations and the three GNSS antenna piers.

- The residuals of the distances and directions were consistent among all stations.
- The sum squares of standard residuals is 13.436 with a total error factor of 0.389.
- The Chi-square test at 5 % level exceeded the lower bound of 0.853. Upper bound is 1.147.

See Attachment A. 3-Dimensional Adjustment Results (STAR*NET 3D.lst) for additional details.

A few things one should note when reviewing the 3-D adjustment output file. The error factor for zeniths can safely be ignored. It is suspected that ground-level refraction caused vertical pointing of the tacheometer to be more erratic to network stations, but with a definite bias. Imprecise pointing increases residual spread. Constraining the elevations at these points reveals the bias. Both of these conditions, present in this adjustment, adversely affected the error factor.

Table 4 contains the adjusted geocentric coordinates for all stations in IGS08(2012.076).

Station Name	X (m)	X σ (m)	Y (m)	Yσ (m)	Z (m)	Xσ (m)
7550004	1097071.2918	0.0003	-4897222.5644	0.0003	3923134.8722	0.0004
BLDG 11	1097036.6834	0.0001	-4897251.7268	0.0001	3923108.7472	0.0001
CORBIN N PIER ADAPTER	1097041.7179	0.0003	-4897241.5996	0.0003	3923122.3044	0.0003
CORBIN CORS ARP	1097041.2147	0.0003	-4897238.4280	0.0003	3923126.2782	0.0003
CORBIN QUAD CP	1097038.9281	0.0001	-4897223.9998	0.0003	3923141.9723	0.0003
CORBIN S PIER ADAPTER	1097042.3197	0.0003	-4897244.6189	0.0003	3923118.3991	0.0003

Table 4 - Adjusted coordinates transformed to IGS08(2012.076) using AXIS software.

During a local tie survey, personnel may not have the luxury of removing a GNSS antenna to make a direct tie to the antenna adapter installed in the pier. On those occasions, an indirect intersection tie is made to the antenna's lowest

symmetrical feature, usually the bottom of the preamplifier from three network stations that form a triangle around the antenna pier. The antenna is used as a target and is observed from each of the three stations.

The left bottom edge and right bottom edge of the feature are treated as separate targets during an observation run from each of the three network stations. Figure 5 can be used to roughly illustrate tacheometer pointing on the antenna. The mean of the resulting two horizontal directions and two zenith distances coincide with a fixed point along the antenna's vertical axis of rotation with a known vertical offset relative to the antenna reference point (ARP, also along the vertical rotation axis).

By combining horizontal directions from each of the three network stations, a relative horizontal position (N,E) is determined, along with horizontal distances between each of the three stations and the fixed point along the antenna's vertical axis of rotation. Observed zenith distances are added to compute a height (U) relative to the network stations. The known vertical offset of the fixed point, if any, is applied to reduce the height to the ARP. Observations from two network stations laid out at approximately 90^{O} in arc from each other (when viewed from the antenna pier) would be sufficient to determine a relative position. The third network station is for redundancy.

Table 5 shows how well indirect intersection observations compare to traditional direct observations. The positions of the two stations listed were determined independently using both methods. Each station is listed twice; first, with coordinates from direct observations with the antenna removed; and second with the antenna in place, coordinates from indirect intersection observations involving left and right tangents of the bottom of the antenna's preamplifier. Tacheometer pointings on the choke ring were made to the same location as leveling observations shown in Figure 5.

Station Name	X (m)	Y (m)	Z (m)	delta	mm	mm	mm
CORBIN N PIER ADAPTER	1097041.7179	-4897241.5996	3923122.3044	XYZ	0.0	0.3	0.7
CORBIN N PIER ADAPTER (INT)	1097041.7179	-4897241.5993	3923122.3051	NEU	0.7	0.1	0.2
CORBIN CORS ARP	1097041.2147	-4897238.4280	3923126.2782	XYZ	0.1	-0.3	-0.2
CORBIN CORS ARP (INT)	1097041.2148	-4897238.4283	3923126.2780	NEU	-0.4	0.0	0.1

Table 5 - Results of direct and indirect tacheometer observations in IGS08(2012.076). [Note: indirect (INT) minus direct]

5.7 Comparison with Previous Surveys

Prior to the installation of CORB in 1999, in August, 1994 the NGS Instrumentation & Equipment Section (currently the Instrumentation & Methodologies Branch) conducted a geodetic leveling survey at the site to tie CORBIN N PIER ADAPTER (CNPA) and CORBIN S PIER ADAPTER (CSPA) to three vertical control marks 7550002, 7550003 and 7550004. Table 6 contains height difference comparisons between network stations common to the 1994 and 2012 survey. See Attachment H. 1994 Leveling Report. Also, see Attachment I. 1994 Leveling Field Abstract.

Source	From	To	ΔH (m)
1994	7550004	CORBIN N PIER ADAPTER	1.7448
2012	7550004	CORBIN N PIER ADAPTER	1.7442
		New minus Old	-0.0006
1994	CORBIN N PIER ADAPTER	CORBIN S PIER ADAPTER	0.0027
2012	CORBIN N PIER ADAPTER	CORBIN S PIER ADAPTER	0.0034
		New minus Old	0.0007

Table 6. Height difference comparisons, NGS 1994 versus 2012 NGS survey

In November, 1995 the NGS Instrumentation & Equipment Section conducted a 3-D survey at the site to tie relative antenna calibration pier CORBIN N PIER ADAPTER to CORBIN S PIER ADAPTER. Included in that survey were control stations ASTRO EAST PIER, CORBIN QUAD 2, CORBIN QUAD 3, and CORBIN QUAD 4. Table 7 contains topocentric vector comparisons between these two piers during the 1995 and 2012 survey. See Attachment J. 1995 3-D Project Report for further details. NGS Program HTDP was used to transform and update the previous survey's coordinates from NAD83(1993) to IGS08 (2012.076).

Station Name IGS08(2012.076)	X (m)	Y (m)	Z (m)	N (m)	E (m)	U (m)
CORBIN N PIER ADAPTER (1995)	1097041.651	-4897241.256	3923122.051	0.000	0.000	0.000
CORBIN S PIER ADAPTER (1995)	1097042.252	-4897244.276	3923118.146	-4.972	-0.074	0.004
CORBIN N PIER ADAPTER (2012)	1097041.7179	-4897241.5996	3923122.3044	0.000	0.000	0.000
CORBIN S PIER ADAPTER (2012)	1097042.3197	-4897244.6189	3923118.3991	-4.972	-0.073	0.004
			Topocentric vector differences:	0.000	0.001	-0.000

Table 7. Topocentric vector comparisons, 2012 3-D survey versus 1995 3-D survey in IGS08(2012.076)

The comparisons in Table 7 have several implications:

- The surveying equipment and methods currently employed yield results that are very favorable to the more intensive survey performed in 1995. Highly accurate, convenient, and user-friendly electronic distance measuring equipment means less reliance on horizontal directions and azimuth observations, which in turn means the local network is not spread out over a large area.
- The simple, inexpensive design of the forced-centering piers used for CORBIN N and S PIER ADAPTER is highly suitable for the local soil conditions. The two piers have maintained a high level of stability for 17 years, even through the earthquake of 2011.
- Careful setup and longer GPS sessions under good conditions yielded millimeter or better results.
- OPUS Projects works extremely well GPS processing and adjustment of local-tie surveys.

6. Planning Aspects

- Contact NGS's Instrumentation and Methodology Branch Chief at 540-373-1243.

7. References

7.1 Name of person responsible for observations

Kendall Fancher
National Geodetic Survey
P.O. Box 190
Corbin, VA 22446
Phone – (540) 373-1243
Email – kendall.fancher@noaa.gov

7.2 Name of person(s) responsible for analysis

Kendall Fancher (kendall.fancher@noaa.gov)
Steven Breidenbach (steven.breidenbach@noaa.gov)
Charles Geoghegan (charles.geoghegan@noaa.gov)
National Geodetic Survey
P.O. Box 190
Corbin, VA 22446
Phone – (540) 373-1243

7.3 Location of observation data and results archive

National Geodetic Survey
Instrumentation & Methodologies Branch
P.O. Box 190
Corbin, VA 22446
(540) 373-1243

A. 3-D Adjustment Results (STAR*NET 3-D LST file)

```
      MicroSurvey STAR*NET-PRO Version 7.1.0.5
                  Run Date: Wed Apr 11 2012 09:54:26


               Summary of Files Used and Option Settings
               =========================================

                     Project Folder and Data Files

Project Name       3D
Project Folder     C:\ISS PROGRAM\FY12\CORBIN CORS\3-D ADJUSTMENT
Data File List  1. 3D.dat

                        Project Option Settings

STAR*NET Run Mode                   : Adjust with Error Propagation
Type of Adjustment                  : 3D
Project Units                       : Meters; DMS
Coordinate System                   : LOCAL
Apply Average Scale Factor          : 1.0000000000
Input/Output Coordinate Order       : North-East
Angle Data Station Order            : At-From-To
Distance/Vertical Data Type         : Slope/Zenith
Convergence Limit; Max Iterations   : 0.010000; 10
Default Coefficient of Refraction   : 0.070000
Earth Radius                        : 6372000.00 Meters
Create Coordinate File              : Yes
Create Ground Scale Coordinate File : No
Create Dump File                    : Yes

                   Instrument Standard Error Settings

Project Default Instrument
  Distances (Constant)              :    0.000300 Meters
  Distances (PPM)                   :    1.000000
  Angles                            :    0.500000 Seconds
  Directions                        :    0.500000 Seconds
  Azimuths & Bearings               :    0.500000 Seconds
  Zeniths                           :    3.000000 Seconds
  Elevation Differences (Constant)  :    0.000500 Meters
  Elevation Differences (PPM)       :    3.000000
  Differential Levels               :    0.003000 Meters / Km
  Centering Error Instrument        :    0.000500 Meters
  Centering Error Target            :    0.000500 Meters
  Centering Error Vertical          :    0.000500 Meters
```

Summary of Unadjusted Input Observations

Number of Entered Stations (Meters) = 3

Partially Fixed	N	E	Elev	Description
	StdErr	StdErr	StdErr	
BLDG_11	0.0000	0.0000	66.8850	
	0.0001	0.0001	0.0001	
CORBIN_CORS_INT	n/a	n/a	68.3074	
			0.0007	
CORB_N_PIER_INT	n/a	n/a	68.3684	
			0.0007	

Number of Distance Observations (Meters) = 30

From	To	Distance	StdErr	HI	HT	Type
BLDG_11	CORBIN_QUA	43.3329	0.0008	1.641	1.593	S
BLDG_11	CORBIN_COR	22.4211	0.0008	1.641	0.237	S
BLDG_11	CORBIN_N_P	17.5931	0.0008	1.641	0.238	S
BLDG_11	CORBIN_S_P	13.1622	0.0008	1.641	0.237	S
BLDG_11	7550004	52.2569	0.0008	1.641	1.515	S
CORBIN_QUA	BLDG_11	43.3331	0.0008	1.593	1.641	S
CORBIN_QUA	CORBIN_N_P	26.4821	0.0008	1.593	0.238	S
CORBIN_QUA	CORBIN_S_P	31.4527	0.0008	1.593	0.237	S
CORBIN_QUA	7550004	33.1645	0.0008	1.593	1.515	S
CORBIN_QUA	CORBIN_COR	21.3727	0.0008	1.593	0.237	S
7550004	BLDG_11	52.2568	0.0008	1.515	1.641	S
7550004	CORBIN_S_P	39.9288	0.0008	1.515	0.237	S
7550004	CORBIN_N_P	37.3107	0.0008	1.515	0.238	S
7550004	CORBIN_COR	35.0352	0.0008	1.515	0.237	S
7550004	CORBIN_QUA	33.1644	0.0008	1.515	1.593	S
CORBIN_COR	BLDG_11	22.4212	0.0008	0.237	1.641	S
CORBIN_COR	CORBIN_QUA	21.3726	0.0008	0.237	1.593	S
CORBIN_COR	7550004	35.0352	0.0008	0.237	1.515	S
CORBIN_COR	CORBIN_S_P	10.0812	0.0008	0.237	0.237	S
CORBIN_COR	CORBIN_N_P	5.1088	0.0008	0.237	0.238	S
CORBIN_N_P	BLDG_11	17.5930	0.0008	0.238	1.641	S
CORBIN_N_P	CORBIN_QUA	26.4819	0.0008	0.238	1.593	S
CORBIN_N_P	7550004	37.3107	0.0008	0.238	1.515	S
CORBIN_N_P	CORBIN_S_P	4.9728	0.0008	0.238	0.237	S
CORBIN_N_P	CORBIN_COR	5.1089	0.0008	0.238	0.237	S
CORBIN_S_P	BLDG_11	13.1624	0.0008	0.237	1.641	S
CORBIN_S_P	CORBIN_COR	10.0812	0.0008	0.237	0.237	S
CORBIN_S_P	CORBIN_QUA	31.4527	0.0008	0.237	1.593	S
CORBIN_S_P	7550004	39.9288	0.0008	0.237	1.515	S
CORBIN_S_P	CORBIN_N_P	4.9728	0.0008	0.237	0.238	S

Number of Zenith Observations (DMS) = 30

From	To	Zenith	StdErr	HI	HT
BLDG_11	CORBIN_QUA	90-29-52.90	4.51	1.641	1.593
BLDG_11	CORBIN_COR	89-57-05.30	7.16	1.641	0.237
BLDG_11	CORBIN_N_P	89-44-06.60	8.82	1.641	0.238
BLDG_11	CORBIN_S_P	89-38-12.65	11.48	1.641	0.237
BLDG_11	7550004	90-25-26.40	4.10	1.641	1.515
CORBIN_QUA	BLDG_11	89-30-03.90	4.51	1.593	1.641
CORBIN_QUA	CORBIN_N_P	89-00-31.80	6.27	1.593	0.238
CORBIN_QUA	CORBIN_S_P	89-09-40.80	5.52	1.593	0.237
CORBIN_QUA	7550004	90-00-59.70	5.32	1.593	1.515
CORBIN_QUA	CORBIN_COR	88-56-20.90	7.45	1.593	0.237

From	To	Zenith	StdErr	HI	HT
7550004	BLDG_11	89-34-32.60	4.10	1.515	1.641
7550004	CORBIN_S_P	89-19-30.90	4.73	1.515	0.237
7550004	CORBIN_N_P	89-16-52.70	4.93	1.515	0.238
7550004	CORBIN_COR	89-20-11.60	5.13	1.515	0.237
7550004	CORBIN_QUA	89-58-55.50	5.32	1.515	1.593
CORBIN_COR	BLDG_11	90-02-45.70	7.16	0.237	1.641
CORBIN_COR	CORBIN_QUA	91-03-30.30	7.45	0.237	1.593
CORBIN_COR	7550004	90-39-44.70	5.13	0.237	1.515
CORBIN_COR	CORBIN_S_P	89-37-45.20	14.78	0.237	0.237
CORBIN_COR	CORBIN_N_P	89-17-36.90	28.71	0.237	0.238
CORBIN_N_P	BLDG_11	90-15-42.40	8.82	0.238	1.641
CORBIN_N_P	CORBIN_QUA	90-59-21.30	6.27	0.238	1.593
CORBIN_N_P	7550004	90-43-04.70	4.93	0.238	1.515
CORBIN_N_P	CORBIN_S_P	89-58-08.20	29.48	0.238	0.237
CORBIN_N_P	CORBIN_COR	90-41-43.30	28.71	0.238	0.237
CORBIN_S_P	BLDG_11	90-21-34.80	11.48	0.237	1.641
CORBIN_S_P	CORBIN_COR	90-21-53.50	14.78	0.237	0.237
CORBIN_S_P	CORBIN_QUA	90-50-14.77	5.52	0.237	1.593
CORBIN_S_P	7550004	90-40-28.30	4.73	0.237	1.515
CORBIN_S_P	CORBIN_N_P	90-01-10.80	29.48	0.237	0.238

Number of Differential Level Observations (Meters) = 14

From	To	Elev Diff	StdErr	Length
CORBIN_QUA	7550004	0.0677	0.0005	n/a
7550004	BLDG_11	0.2608	0.0007	n/a
BLDG_11	7550004	-0.2608	0.0007	n/a
7550004	CORBIN_QUA	-0.0677	0.0005	n/a
CORBIN_N_P	CORBIN_S_P	0.0034	0.0004	n/a
CORBIN_S_P	BLDG_11	-1.4868	0.0005	n/a
BLDG_11	CORBIN_S_P	1.4868	0.0005	n/a
CORBIN_S_P	CORBIN_N_P	-0.0034	0.0004	n/a
CORBIN_COR	CORBIN_QUA	-1.7509	0.0005	n/a
CORBIN_QUA	CORBIN_COR	1.7509	0.0005	n/a
CORBIN_QUA	CORBIN_COR	1.7509	0.0005	n/a
CORBIN_QUA	CORBIN_S_P	1.8153	0.0005	n/a
CORBIN_N_P	CORBIN_COR	-0.0610	0.0003	n/a
CORBIN_COR	CORBIN_N_P	0.0610	0.0003	n/a

Number of Direction Observations (DMS) = 42

From	To	Direction	StdErr
Set 1			
BLDG_11	CORBIN_QUA	0-00-00.00	3.40
BLDG_11	CORBIN_COR	8-06-07.10	6.52
BLDG_11	CORBIN_N_P	12-55-09.50	8.31
BLDG_11	CORBIN_S_P	21-25-46.60	11.09
BLDG_11	7550004	39-13-14.70	2.84
Set 2			
CORBIN_QUA	BLDG_11	0-00-00.00	3.40
CORBIN_QUA	CORBIN_N_P	351-27-27.40	5.53
CORBIN_QUA	CORBIN_S_P	351-12-19.50	4.66
CORBIN_QUA	7550004	274-55-40.60	4.43
CORBIN_QUA	CORBIN_COR	351-29-52.20	6.84

From	To	Direction	StdErr
Set 3			
7550004	BLDG_11	0-00-00.00	2.84
7550004	CORBIN_S_P	5-46-54.70	3.69
7550004	CORBIN_N_P	12-03-38.80	3.94
7550004	CORBIN_COR	19-18-57.20	4.19
7550004	CORBIN_QUA	55-42-22.00	4.43
Set 4			
CORBIN_COR	BLDG_11	0-00-00.00	6.52
CORBIN_COR	CORBIN_QUA	163-23-46.40	6.84
CORBIN_COR	7550004	230-26-07.90	4.19
CORBIN_COR	CORBIN_S_P	342-29-09.00	14.48
CORBIN_COR	CORBIN_N_P	343-11-33.50	28.55
Set 5			
CORBIN_N_P	BLDG_11	0-00-00.00	8.31
CORBIN_N_P	CORBIN_QUA	158-32-22.10	5.53
CORBIN_N_P	7550004	218-21-48.90	3.94
CORBIN_N_P	CORBIN_S_P	336-56-39.90	29.33
CORBIN_N_P	CORBIN_COR	158-22-33.80	28.55
Set 6			
CORBIN_S_P	BLDG_11	0-00-00.00	11.09
CORBIN_S_P	CORBIN_COR	149-09-26.60	14.48
CORBIN_S_P	CORBIN_QUA	149-46-32.30	4.66
CORBIN_S_P	7550004	203-34-23.40	3.69
CORBIN_S_P	CORBIN_N_P	148-26-03.30	29.33
Set 7			
BLDG_11	CORBIN_QUA	0-00-00.00	3.40
BLDG_11	CORBIN_COR	8-06-02.50	6.52
BLDG_11	CORB_N_PIE	12-55-01.70	8.30
BLDG_11	7550004	39-13-14.30	2.84
Set 8			
CORBIN_QUA	7550004	0-00-00.00	4.43
CORBIN_QUA	CORB_N_PIE	76-31-45.35	5.53
CORBIN_QUA	CORBIN_COR	76-34-05.35	6.84
CORBIN_QUA	BLDG_11	85-04-19.30	3.40
Set 9			
7550004	BLDG_11	0-00-00.00	2.84
7550004	CORB_N_PIE	12-03-42.50	3.94
7550004	CORBIN_COR	19-18-52.95	4.19
7550004	CORBIN_QUA	55-42-23.90	4.43

Number of Azimuth/Bearing Observations (DMS) = 1

From	To	Bearing	StdErr
BLDG_11	CORBIN_QUA	N00-00-00.00E	0.10

Adjustment Statistical Summary

Iterations = 2

Number of Stations = 8

Number of Observations = 122
Number of Unknowns = 33
Number of Redundant Obs = 89

Observation	Count	Sum Squares of StdRes	Error Factor
Coordinates	5	0.000	0.000
Directions	42	2.174	0.266
Distances	30	1.109	0.225
Az/Bearings	1	0.000	0.000
Zeniths	30	9.650	0.664
Level Data	14	0.504	0.222
Total	122	13.436	0.389

Warning: The Chi-Square Test at 5.00% Level Exceeded Lower Bound
Lower/Upper Bounds (0.853/1.147)

Adjusted Coordinates (Meters)

Station	N	E	Elev	Description
BLDG_11	-0.0000	0.0000	66.8850	
CORBIN_CORS_INT	22.1970	3.1598	68.3074	
CORB_N_PIER_INT	17.1482	3.9331	68.3684	
CORBIN_QUAD_CP	43.3316	0.0000	66.5562	
7550004	40.4829	33.0418	66.6240	
CORBIN_N_PIER_A	17.1474	3.9332	68.3683	
CORBIN_S_PIER_A	12.2522	4.8086	68.3717	
CORBIN_CORS_ARP	22.1973	3.1597	68.3072	

Adjusted Observations and Residuals

Adjusted Coordinate Observations (Meters)
(Stations with Partially Fixed Coordinate Components)

Station	Component	Adj Coordinate	Residual	StdErr	StdRes	File:Line
BLDG_11	N	-0.0000	-0.0000	0.0001	0.0	1:3
	E	0.0000	0.0000	0.0001	0.0	1:3
	Elev	66.8850	-0.0000	0.0001	0.0	1:3
CORBIN_CORS_INT	Elev	68.3074	-0.0000	0.0007	0.0	1:4
CORB_N_PIER_INT	Elev	68.3684	-0.0000	0.0007	0.0	1:5

Adjusted Distance Observations (Meters)

From	To	Distance	Residual	StdErr	StdRes	File:Line
BLDG_11	CORBIN_QUA	43.3332	0.0003	0.0008	0.4	1:24
BLDG_11	CORBIN_COR	22.4211	0.0000	0.0008	0.0	1:25
BLDG_11	CORBIN_N_P	17.5929	-0.0002	0.0008	0.2	1:26
BLDG_11	CORBIN_S_P	13.1622	0.0000	0.0008	0.1	1:27
BLDG_11	7550004	52.2569	-0.0000	0.0008	0.0	1:28
CORBIN_QUA	BLDG_11	43.3332	0.0001	0.0008	0.2	1:31
CORBIN_QUA	CORBIN_N_P	26.4819	-0.0002	0.0008	0.3	1:32
CORBIN_QUA	CORBIN_S_P	31.4526	-0.0001	0.0008	0.1	1:33
CORBIN_QUA	7550004	33.1644	-0.0001	0.0008	0.2	1:34
CORBIN_QUA	CORBIN_COR	21.3728	0.0001	0.0008	0.1	1:35
7550004	BLDG_11	52.2569	0.0001	0.0008	0.1	1:38
7550004	CORBIN_S_P	39.9289	0.0001	0.0008	0.1	1:39
7550004	CORBIN_N_P	37.3106	-0.0001	0.0008	0.2	1:40
7550004	CORBIN_COR	35.0352	0.0000	0.0008	0.0	1:41
7550004	CORBIN_QUA	33.1644	-0.0000	0.0008	0.0	1:42
CORBIN_COR	BLDG_11	22.4211	-0.0001	0.0008	0.1	1:46
CORBIN_COR	CORBIN_QUA	21.3728	0.0002	0.0008	0.2	1:47
CORBIN_COR	7550004	35.0352	0.0000	0.0008	0.0	1:48
CORBIN_COR	CORBIN_S_P	10.0812	-0.0000	0.0008	0.1	1:49
CORBIN_COR	CORBIN_N_P	5.1092	0.0004	0.0008	0.5	1:50
CORBIN_N_P	BLDG_11	17.5929	-0.0001	0.0008	0.1	1:53
CORBIN_N_P	CORBIN_QUA	26.4819	-0.0000	0.0008	0.0	1:54
CORBIN_N_P	7550004	37.3106	-0.0001	0.0008	0.2	1:55
CORBIN_N_P	CORBIN_S_P	4.9729	0.0001	0.0008	0.2	1:56
CORBIN_N_P	CORBIN_COR	5.1092	0.0003	0.0008	0.4	1:57
CORBIN_S_P	BLDG_11	13.1622	-0.0002	0.0008	0.2	1:60
CORBIN_S_P	CORBIN_COR	10.0812	-0.0000	0.0008	0.1	1:61
CORBIN_S_P	CORBIN_QUA	31.4526	-0.0001	0.0008	0.1	1:62
CORBIN_S_P	7550004	39.9289	0.0001	0.0008	0.1	1:63
CORBIN_S_P	CORBIN_N_P	4.9729	0.0001	0.0008	0.2	1:64

Adjusted Zenith Observations (DMS)

From	To	Zenith	Residual	StdErr	StdRes	File:Line
BLDG_11	CORBIN_QUA	90-29-53.48	0-00-00.58	4.51	0.1	1:24
BLDG_11	CORBIN_COR	89-57-09.00	0-00-03.70	7.16	0.5	1:25
BLDG_11	CORBIN_N_P	89-44-12.31	0-00-05.71	8.82	0.6	1:26
BLDG_11	CORBIN_S_P	89-38-16.15	0-00-03.50	11.48	0.3	1:27
BLDG_11	7550004	90-25-27.54	0-00-01.14	4.10	0.3	1:28
CORBIN_QUA	BLDG_11	89-30-07.72	0-00-03.82	4.51	0.8	1:31
CORBIN_QUA	CORBIN_N_P	89-00-36.72	0-00-04.92	6.27	0.8	1:32
CORBIN_QUA	CORBIN_S_P	89-09-44.54	0-00-03.74	5.52	0.7	1:33
CORBIN_QUA	7550004	90-01-03.64	0-00-03.94	5.32	0.7	1:34
CORBIN_QUA	CORBIN_COR	88-56-25.35	0-00-04.45	7.45	0.6	1:35
7550004	BLDG_11	89-34-33.92	0-00-01.32	4.10	0.3	1:38

From	To	Zenith	Residual	StdErr	StdRes	File:Line
7550004	CORBIN_S_P	89-19-32.44	0-00-01.54	4.73	0.3	1:39
7550004	CORBIN_N_P	89-16-55.06	0-00-02.36	4.93	0.5	1:40
7550004	CORBIN_COR	89-20-13.50	0-00-01.90	5.13	0.4	1:41
7550004	CORBIN_QUA	89-58-57.28	0-00-01.78	5.32	0.3	1:42
CORBIN_COR	BLDG_11	90-02-49.79	0-00-04.09	7.16	0.6	1:46
CORBIN_COR	CORBIN_QUA	91-03-34.28	0-00-03.98	7.45	0.5	1:47
CORBIN_COR	7550004	90-39-45.71	0-00-01.01	5.13	0.2	1:48
CORBIN_COR	CORBIN_S_P	89-37-56.53	0-00-11.33	14.78	0.8	1:49
CORBIN_COR	CORBIN_N_P	89-17-55.59	0-00-18.69	28.71	0.7	1:50
CORBIN_N_P	BLDG_11	90-15-49.35	0-00-06.95	8.82	0.8	1:53
CORBIN_N_P	CORBIN_QUA	90-59-25.57	0-00-04.27	6.27	0.7	1:54
CORBIN_N_P	7550004	90-43-05.98	0-00-01.28	4.93	0.3	1:55
CORBIN_N_P	CORBIN_S_P	89-58-30.44	0-00-22.24	29.48	0.8	1:56
CORBIN_N_P	CORBIN_COR	90-42-04.55	0-00-21.25	28.71	0.7	1:57
CORBIN_S_P	BLDG_11	90-21-42.65	0-00-07.85	11.48	0.7	1:60
CORBIN_S_P	CORBIN_COR	90-22-03.75	0-00-10.25	14.78	0.7	1:61
CORBIN_S_P	CORBIN_QUA	90-50-16.33	0-00-01.56	5.52	0.3	1:62
CORBIN_S_P	7550004	90-40-27.63	-0-00-00.67	4.73	0.1	1:63
CORBIN_S_P	CORBIN_N_P	90-01-29.70	0-00-18.90	29.48	0.6	1:64

Adjusted Differential Level Observations (Meters)

From	To	Elev Diff	Residual	StdErr	StdRes	File:Line
CORBIN_QUA	7550004	0.0677	0.0000	0.0005	0.1	1:7
7550004	BLDG_11	0.2610	0.0002	0.0007	0.3	1:8
BLDG_11	7550004	-0.2610	-0.0002	0.0007	0.3	1:9
7550004	CORBIN_QUA	-0.0677	-0.0000	0.0005	0.1	1:10
CORBIN_N_P	CORBIN_S_P	0.0035	0.0001	0.0004	0.2	1:11
CORBIN_S_P	BLDG_11	-1.4867	0.0001	0.0005	0.2	1:12
BLDG_11	CORBIN_S_P	1.4867	-0.0001	0.0005	0.2	1:13
CORBIN_S_P	CORBIN_N_P	-0.0035	-0.0001	0.0004	0.2	1:14
CORBIN_COR	CORBIN_QUA	-1.7510	-0.0001	0.0005	0.2	1:15
CORBIN_QUA	CORBIN_COR	1.7510	0.0001	0.0005	0.2	1:16
CORBIN_QUA	CORBIN_COR	1.7510	0.0001	0.0005	0.2	1:17
CORBIN_QUA	CORBIN_S_P	1.8155	0.0002	0.0005	0.3	1:18
CORBIN_N_P	CORBIN_COR	-0.0610	-0.0000	0.0003	0.1	1:19
CORBIN_COR	CORBIN_N_P	0.0610	0.0000	0.0003	0.1	1:20

Adjusted Direction Observations (DMS)

From	To	Direction	Residual	StdErr	StdRes	File:Line
Set 1						
BLDG_11	CORBIN_QUA	0-00-00.02	0-00-00.02	3.40	0.0	1:24
BLDG_11	CORBIN_COR	8-06-05.20	-0-00-01.90	6.52	0.3	1:25
BLDG_11	CORBIN_N_P	12-55-07.11	-0-00-02.39	8.31	0.3	1:26
BLDG_11	CORBIN_S_P	21-25-42.12	-0-00-04.48	11.09	0.4	1:27
BLDG_11	7550004	39-13-15.62	0-00-00.92	2.84	0.3	1:28
Set 2						
CORBIN_QUA	BLDG_11	0-00-01.06	0-00-01.06	3.40	0.3	1:31
CORBIN_QUA	CORBIN_N_P	351-27-27.67	0-00-00.27	5.53	0.0	1:32
CORBIN_QUA	CORBIN_S_P	351-12-19.11	-0-00-00.39	4.66	0.1	1:33
CORBIN_QUA	7550004	274-55-40.02	-0-00-00.58	4.43	0.1	1:34
CORBIN_QUA	CORBIN_COR	351-29-49.74	-0-00-02.46	6.84	0.4	1:35

From	To	Direction	Residual	StdErr	StdRes	File:Line
Set 3						
7550004	BLDG_11	0-00-00.22	0-00-00.22	2.84	0.1	1:38
7550004	CORBIN_S_P	5-46-53.55	-0-00-01.15	3.69	0.3	1:39
7550004	CORBIN_N_P	12-03-39.51	0-00-00.71	3.94	0.2	1:40
7550004	CORBIN_COR	19-18-55.98	-0-00-01.22	4.19	0.3	1:41
7550004	CORBIN_QUA	55-42-23.58	0-00-01.58	4.43	0.4	1:42
Set 4						
CORBIN_COR	BLDG_11	0-00-01.70	0-00-01.70	6.52	0.3	1:46
CORBIN_COR	CORBIN_QUA	163-23-45.19	-0-00-01.21	6.84	0.2	1:47
CORBIN_COR	7550004	230-26-07.88	-0-00-00.02	4.19	0.0	1:48
CORBIN_COR	CORBIN_S_P	342-29-07.46	-0-00-01.54	14.48	0.1	1:49
CORBIN_COR	CORBIN_N_P	343-11-28.88	-0-00-04.62	28.55	0.2	1:50
Set 5						
CORBIN_N_P	BLDG_11	0-00-01.52	0-00-01.52	8.31	0.2	1:53
CORBIN_N_P	CORBIN_QUA	158-32-21.04	-0-00-01.06	5.53	0.2	1:54
CORBIN_N_P	7550004	218-21-49.33	0-00-00.43	3.94	0.1	1:55
CORBIN_N_P	CORBIN_S_P	336-56-34.52	-0-00-05.38	29.33	0.2	1:56
CORBIN_N_P	CORBIN_COR	158-22-26.80	-0-00-07.00	28.55	0.2	1:57
Set 6						
CORBIN_S_P	BLDG_11	359-59-56.82	-0-00-03.18	11.09	0.3	1:60
CORBIN_S_P	CORBIN_COR	149-09-25.66	-0-00-00.94	14.48	0.1	1:61
CORBIN_S_P	CORBIN_QUA	149-46-32.77	0-00-00.47	4.66	0.1	1:62
CORBIN_S_P	7550004	203-34-23.65	0-00-00.25	3.69	0.1	1:63
CORBIN_S_P	CORBIN_N_P	148-25-54.80	-0-00-08.50	29.33	0.3	1:64
Set 7						
BLDG_11	CORBIN_QUA	359-59-58.84	-0-00-01.16	3.40	0.3	1:68
BLDG_11	CORBIN_COR	8-06-05.30	0-00-02.80	6.52	0.4	1:69
BLDG_11	CORB_N_PIE	12-55-02.88	0-00-01.18	8.30	0.1	1:72
BLDG_11	7550004	39-13-14.44	0-00-00.14	2.84	0.0	1:73
Set 8						
CORBIN_QUA	7550004	359-59-58.39	-0-00-01.61	4.43	0.4	1:76
CORBIN_QUA	CORB_N_PIE	76-31-45.91	0-00-00.56	5.53	0.1	1:77
CORBIN_QUA	CORBIN_COR	76-34-07.81	0-00-02.46	6.84	0.4	1:78
CORBIN_QUA	BLDG_11	85-04-19.43	0-00-00.13	3.40	0.0	1:81
Set 9						
7550004	BLDG_11	359-59-59.89	-0-00-00.11	2.84	0.0	1:84
7550004	CORB_N_PIE	12-03-42.74	0-00-00.24	3.94	0.1	1:85
7550004	CORBIN_COR	19-18-53.51	0-00-00.56	4.19	0.1	1:86
7550004	CORBIN_QUA	55-42-23.25	-0-00-00.65	4.43	0.1	1:89

Adjusted Azimuth/Bearing Observations (DMS)

From	To	Bearing	Residual	StdErr	StdRes	File:Line
BLDG_11	CORBIN_QUA	N00-00-00.00E	0-00-00.00	0.10	0.0	1:21

Adjusted Bearings (DMS) and Horizontal Distances (Meters)

(Relative Confidence of Bearing is in Seconds)

From	To	Bearing	Distance	95% RelConfidence Brg	Dist	PPM
7550004	BLDG_11	S39-13-15.60W	52.2554	3.75	0.0008	14.4727
7550004	CORBIN_COR	S58-32-11.37W	35.0329	5.85	0.0007	21.3877
7550004	CORBIN_COR	S58-32-09.23W	35.0330	11.90	0.0020	57.7251
7550004	CORBIN_N_P	S51-16-54.90W	37.3076	5.66	0.0008	20.1196
7550004	CORBIN_QUA	N85-04-21.04W	33.1644	5.29	0.0008	23.7602
7550004	CORBIN_S_P	S45-00-08.94W	39.9261	5.47	0.0008	19.0173
7550004	CORB_N_PIE	S51-16-58.45W	37.3072	11.06	0.0025	66.1826
BLDG_11	CORBIN_COR	N08-06-05.19E	22.4211	6.03	0.0008	34.4488
BLDG_11	CORBIN_COR	N08-06-06.46E	22.4208	11.44	0.0025	111.2734
BLDG_11	CORBIN_N_P	N12-55-07.09E	17.5927	7.89	0.0008	43.6224
BLDG_11	CORBIN_QUA	N00-00-00.00E	43.3316	0.24	0.0007	17.2997
BLDG_11	CORBIN_S_P	N21-25-42.11E	13.1620	11.13	0.0008	58.0771
BLDG_11	CORB_N_PIE	N12-55-04.04E	17.5934	14.24	0.0029	162.3254
CORBIN_COR	CORBIN_N_P	S08-42-27.63E	5.1088	29.43	0.0008	151.3131
CORBIN_COR	CORBIN_QUA	N08-30-11.32W	21.3691	6.33	0.0008	35.2528
CORBIN_COR	CORBIN_S_P	S09-24-49.05E	10.0809	15.56	0.0008	76.6361
CORBIN_COR	CORBIN_QUA	N08-30-11.62W	21.3695	14.05	0.0024	111.0524
CORBIN_N_P	CORBIN_QUA	N08-32-33.39W	26.4779	5.21	0.0008	28.4549
CORBIN_N_P	CORBIN_S_P	S10-08-19.91E	4.9729	31.03	0.0008	155.3088
CORBIN_QUA	CORBIN_S_P	S08-47-41.95E	31.4492	4.62	0.0008	23.9381
CORBIN_QUA	CORB_N_PIE	S08-32-33.52E	26.4772	12.40	0.0027	100.7143

Error Propagation

Station Coordinate Standard Deviations (Meters)

Station	N	E	Elev
BLDG_11	0.000100	0.000100	0.000100
CORBIN_CORS_INT	0.001009	0.000547	0.000700
CORB_N_PIER_INT	0.001139	0.000574	0.000700
CORBIN_QUAD_CP	0.000322	0.000102	0.000269
7550004	0.000398	0.000329	0.000279
CORBIN_N_PIER_A	0.000331	0.000290	0.000256
CORBIN_S_PIER_A	0.000331	0.000304	0.000240
CORBIN_CORS_ARP	0.000332	0.000285	0.000261

Station Coordinate Error Ellipses (Meters)

Confidence Region = 95

Station	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Elev
BLDG_11	0.000245	0.000245	0-00	0.000196
CORBIN_CORS_INT	0.002512	0.001257	12-15	0.001372
CORB_N_PIER_INT	0.002868	0.001235	14-57	0.001372
CORBIN_QUAD_CP	0.000789	0.000250	0-00	0.000527
7550004	0.001024	0.000740	153-28	0.000546
CORBIN_N_PIER_A	0.000811	0.000709	178-38	0.000503
CORBIN_S_PIER_A	0.000810	0.000743	1-48	0.000470
CORBIN_CORS_ARP	0.000813	0.000697	179-18	0.000512

Relative Error Ellipses (Meters)
Confidence Region = 95

Stations From	To	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Vertical
7550004	BLDG_11	0.000994	0.000698	153-28	0.000510
7550004	CORBIN_COR	0.000994	0.000749	147-33	0.000485
7550004	CORBIN_COR	0.002488	0.001407	13-35	0.001477
7550004	CORBIN_N_P	0.001023	0.000751	140-19	0.000493
7550004	CORBIN_QUA	0.000945	0.000673	146-45	0.000447
7550004	CORBIN_S_P	0.001060	0.000759	133-17	0.000497
7550004	CORB_N_PIE	0.002852	0.001401	16-12	0.001477
BLDG_11	CORBIN_COR	0.000775	0.000652	179-18	0.000473
BLDG_11	CORBIN_COR	0.002500	0.001233	12-15	0.001386
BLDG_11	CORBIN_N_P	0.000774	0.000666	178-38	0.000463
BLDG_11	CORBIN_QUA	0.000750	0.000051	0-00	0.000489
BLDG_11	CORBIN_S_P	0.000772	0.000702	1-48	0.000427
BLDG_11	CORB_N_PIE	0.002857	0.001211	14-57	0.001386
CORBIN_COR	CORBIN_N_P	0.000773	0.000729	175-25	0.000322
CORBIN_COR	CORBIN_QUA	0.000757	0.000652	2-25	0.000378
CORBIN_COR	CORBIN_S_P	0.000773	0.000760	173-23	0.000404
CORBIN_COR	CORBIN_QUA	0.002497	0.001231	12-26	0.001470
CORBIN_N_P	CORBIN_QUA	0.000756	0.000666	0-34	0.000416
CORBIN_N_P	CORBIN_S_P	0.000773	0.000747	160-13	0.000367
CORBIN_QUA	CORBIN_S_P	0.000755	0.000703	3-30	0.000428
CORBIN_QUA	CORB_N_PIE	0.002860	0.001211	14-57	0.001470

Elapsed Time = 00:00:00

29
42
01 00000001 Top of File
01 00000005 Summary of Files Used and Option Settings
02 00000008 Project Folder and Data Files
02 00000014 Project Option Settings
02 00000031 Instrument Standard Error Settings
03 00000033 Project Default Instrument
01 00000047 Summary of Unadjusted Input Observations
02 00000050 Entered Stations
03 00000052 Partially Fixed Coordinates
02 00000061 Distance Observations
02 00000095 Zenith Observations
02 00000129 Differential Level Observations
02 00000147 Direction Observations
02 00000211 Azimuth/Bearing Observations
01 00000216 Adjustment Statistical Summary
01 00000241 Adjusted Coordinates
01 00000254 Adjusted Observations and Residuals
02 00000257 Adjusted Coordinate Observations
02 00000267 Adjusted Distance Observations
02 00000301 Adjusted Zenith Observations
02 00000335 Adjusted Differential Level Observations
02 00000353 Adjusted Direction Observations
02 00000417 Adjusted Azimuth/Bearing Observations
01 00000422 Adjusted Bearings and Horizontal Distances
01 00000450 Error Propagation
02 00000453 Station Coordinate Standard Deviations
02 00000465 Station Coordinate Error Ellipses
02 00000479 Relative Error Ellipses
01 00000505 End of File
000072EE
STAR*NET
0001C4A0

B. Abstract of Leveling Observations

```
TRANSLEV Version 4.16.27              Wed Feb 15 07:25:27 2012


                                              -*- FIELD ABSTRACT -*-
120202-120214              L00000        3.0 MM ORDER 1 CLASS 1     PAGE  1
CORBIN CORS LOCAL TIE

                                        STARTING START   START  DIST   ELEV DIFF      -(F+B) FIELD ELEV  PUB ELEV
SSN  PID    MARK DESIGNATION              DATE    TIME    TEMP   (KM)   (METERS) CODE  (MM)   (METERS)   (METERS)   I S L

0001 HV8189 CORBIN QUAD CP                                                                    68.05600   68.0560
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0001 HV8189 CORBIN QUAD CP            20120202 13:43 F  12.1  0.033    0.06770  *    -0.01    0.06770            1 P
0002 HV7841 7550004                   20120202 14:07 B  11.9  0.033   -0.06769  *                               1 P
                                                          0.033                    -0.01   68.12369   68.1230
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0002 HV7841 7550004                   20120202 13:57 F  12.6  0.052    0.26077  *     0.16    0.26085            1 P
0003        BLDG 11                   20120202 14:02 B  12.4  0.052   -0.26093  *                               1 P
                                                          0.085                     0.15   68.38455
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0003        BLDG 11                   20120202 14:42 B  11.7  0.029   -1.48686  *     0.09    1.48682            1 P
0004 AH4316 CORBIN S PIER ADAPTOR     20120202 14:52 F  12.3  0.028    1.48677  *                               1 P
                                                          0.113                     0.24   69.87136   69.8720
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0004 AH4316 CORBIN S PIER ADAPTOR     20120214 13:59 B  13.1  0.033    1.81541  *     0.00   -1.81541            1 P
0001 HV8189 CORBIN QUAD CP
                                                          0.146                     0.24   68.05595   68.0560
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0004 AH4316 CORBIN S PIER ADAPTOR     20120202 14:36 B  12.1  0.016    0.00338  *@    0.03   -0.00340            1 P
0005 AH4315 CORBIN N PIER ADAPTOR     20120202 15:00 F  12.0  0.016   -0.00341  *@                              1 P
                                                          0.129                     0.27   69.86796   69.8680
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0005 AH4315 CORBIN N PIER ADAPTOR     20120214 15:04 F  12.7  0.010   -0.06089  *    -0.11   -0.06095            1 P
0006 AJ2122 CORBIN CORS ARP           20120214 15:13 B  12.8  0.010    0.06100  *                               1 P
                                                          0.139                     0.16   69.80702
--  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --  --
0001 HV8189 CORBIN QUAD CP            20120214 13:23 B  13.5  0.023   -1.75098  *     0.11    1.75091            1 M
0006 AJ2122 CORBIN CORS ARP           20120214 13:29 F  13.2  0.023    1.75075  *                               1 M
                                      20120214 13:39 F  12.9  0.026    1.75100  *                               1 M
                                                          0.169                     0.35   69.80686
```

ELEVATION REJECTION AND ERROR CODES

* - The section elevation difference does not include rod corrections.
@ - The section elevation difference does not include a refraction correction or the refraction correction is zero.

INSTRUMENT/RODSET	INSTRUMENT	RODS	
1	243 - 332228	396 - 30721	396 - 30721

The shortest path between starting and ending points is:
0001 0006

The shortest distance between starting and ending points is:
0.023 km.

SEGMENT(S) & RUNNING ORDER

--- Survey point numbers ---	length	S	L
0001 0002 0003 0004	0.113	P	
0004 0001	0.033	P	
0004 0005 0006	0.026	P	
0001 0006	0.023	M	

FROM	TO	N. LATITUDE	W. LONGITUDE	FIELD DISTANCE	VS. COMPUTED
0001	0002	381206	0772221	0.03	0.13
0002	0003	381207	0772225	0.05	0.10
0003	0004	381208	0772224	0.03	0.04
0004	0001	381209	0772225	0.03	0.04
0004	0005	381208	0772224	0.02	0.00
0005	0006	381208	0772225	0.01	0.02
0001	0006	381208	0772225	0.02	0.03

* - The observed vs. computed difference exceeds 200 meters

C. Redundant GPS Vectors

DOY	SESS	REF	REM	DELTA X	SIGX	DELTA Y	SIGY	DELTA Z	SIGZ	L (METERS)
12-037	A	bl11	corb	4.5312	2	13.2996	5	17.5306	4	22.4663
12-037	A	cqcp	cor2	2.2868	2	-14.4289	5	-15.6941	4	21.4412
12-037	A	cor2	7554	30.0765	2	15.8643	5	8.5939	4	35.0731
12-037	A	LOY8	cqcp	7976.1499	1	-3926.0613	4	-7001.9822	3	11316.3899
12-037	A	LOYB	LOY8	-16105.3995	0	-35171.0541	0	-38690.0746	0	54711.1397
12-037	A	LOYJ	LOY8	50351.0927	0	-2326.9843	0	-16558.6999	0	53055.0463
12-037	A	LOYM	7554	-61459.7860	1	-21848.8038	4	-9421.9312	3	65904.8429
12-037	A	LOYO	bl11	-4504.5577	1	9657.7522	4	13251.1919	3	17004.6260

DOY	SESS	REF	REM	DELTA X	SIGX	DELTA Y	SIGY	DELTA Z	SIGZ	L (METERS)
12-116	A	bl11	cor2	4.5309	3	13.3012	11	17.5292	8	22.4660
12-116	A	cqcp	cor2	2.2861	3	-14.4273	11	-15.6951	8	21.4409
12-116	A	cor2	7554	30.0769	3	15.8634	11	8.5945	8	35.0732
12-116	A	LOY3	LOYO	7146.9150	1	31392.0831	1	37455.3791	1	49390.7552
12-116	A	LOY8	cqcp	7976.1521	3	-3926.0604	8	-7001.9831	6	11316.3916
12-116	A	LOYB	LOY8	-16105.4001	1	-35171.0539	1	-38690.0742	1	54711.1395
12-116	A	LOYJ	LOY8	50351.0924	1	-2326.9841	1	-16558.6996	1	53055.0458
12-116	A	LOYM	7554	-61459.7846	3	-21848.8022	9	-9421.9323	7	65904.8411
12-116	A	LOYO	bl11	-4504.5564	3	9657.7530	8	13251.1916	6	17004.6259

FROM-TO	AVG. LENGTH (km)	COMBINED XYZ CHANGE (mm)	ALLOWABLE (mm) (0.003 m + 0.1 ppm)
bl11-corb	0.02	2.1	3.0
cqcp-corb	0.02	2.0	3.0
corb-7554	0.04	1.2	3.0
LOY8-cqcp	11.32	2.5	4.1
LOYO-bl11	17.00	1.6	4.7
LOYB-LOY8	54.71	0.7	8.5
LOYJ-LOY8	53.06	0.5	8.3
LOYM-7554	65.90	2.4	9.6

D. Leveling Data Adjustment Results (STAR*NET CORB vertical.lst)

```
     MicroSurvey STAR*NET-PRO Version 7.1.0.5
                 Run Date: Wed Feb 15 2012 11:04:18


              Summary of Files Used and Option Settings
              =========================================

                    Project Folder and Data Files

Project Name       CORB VERTICAL
Project Folder     C:\ISS PROGRAM\FY12\CORBIN CORS\VERTICAL ADJUSTMENT
Data File List  1. CORB vertical.dat

                       Project Option Settings

STAR*NET Run Mode                  : Adjust with Error Propagation
Type of Adjustment                 : Lev
Project Units                      : Meters
Input/Output Coordinate Order      : North-East
Create Coordinate File             : Yes

                  Instrument Standard Error Settings

Project Default Instrument
  Differential Levels              :    0.003000 Meters / Km



                    Summary of Unadjusted Input Observations
                    ========================================

                    Number of Entered Stations (Meters) = 1

Fixed Stations         Elev   Description
BLDG_11              66.8850

            Number of Differential Level Observations (Meters) = 14

From            To                 Elev Diff    StdErr  Length
CORBIN_QUAD_CP  7550004               0.0677    0.0005      33
7550004         BLDG_11               0.2608    0.0007      52
BLDG_11         7550004              -0.2609    0.0007      52
7550004         CORBIN_QUAD_CP       -0.0677    0.0005      33
CORBIN_N_PIER_A CORBIN_S_PIER_A       0.0034    0.0004      16
CORBIN_S_PIER_A BLDG_11              -1.4869    0.0005      29
BLDG_11         CORBIN_S_PIER_A       1.4868    0.0005      28
CORBIN_S_PIER_A CORBIN_N_PIER_A      -0.0034    0.0004      16
CORBIN_CORS_ARP CORBIN_QUAD_CP       -1.7510    0.0005      23
CORBIN_QUAD_CP  CORBIN_CORS_ARP       1.7508    0.0005      23
CORBIN_QUAD_CP  CORBIN_CORS_ARP       1.7510    0.0005      26
CORBIN_QUAD_CP  CORBIN_S_PIER_A       1.8154    0.0005      33
CORBIN_N_PIER_A CORBIN_CORS_ARP      -0.0609    0.0003      10
CORBIN_CORS_ARP CORBIN_N_PIER_A       0.0610    0.0003      10
```

Adjustment Statistical Summary

Number of Stations = 6

Number of Observations = 14
Number of Unknowns = 5
Number of Redundant Obs = 9

Observation Level	Count	Sum Squares of StdRes	Error Factor
Data	14	0.356	0.199
Total	14	0.356	0.199

Warning: The Chi-Square Test at 5.00% Level Exceeded Lower Bound
Lower/Upper Bounds (0.548/1.454)

Adjusted Elevations and Error Propagation (Meters)

Station	Elev	StdDev	95	Description
BLDG_11	66.8850	0.000000	0.000000	
CORBIN_QUAD_CP	66.5565	0.000386	0.000756	
7550004	66.6242	0.000383	0.000750	
CORBIN_N_PIER_A	68.3684	0.000377	0.000739	
CORBIN_S_PIER_A	68.3718	0.000319	0.000626	
CORBIN_CORS_ARP	68.3074	0.000392	0.000767	

Adjusted Observations and Residuals

Adjusted Differential Level Observations (Meters)

From	To	Elev Diff	Residual	StdErr	StdRes	File:Line
CORBIN_QUAD_CP	7550004	0.0677	-0.0000	0.0005	0.0	1:22
7550004	BLDG_11	0.2608	0.0001	0.0007	0.1	1:23
BLDG_11	7550004	-0.2608	0.0001	0.0007	0.1	1:24
7550004	CORBIN_QUAD_CP	-0.0677	0.0000	0.0005	0.0	1:25
CORBIN_N_PIER_A	CORBIN_S_PIER_A	0.0034	0.0000	0.0004	0.1	1:28
CORBIN_S_PIER_A	BLDG_11	-1.4868	0.0001	0.0005	0.1	1:29
BLDG_11	CORBIN_S_PIER_A	1.4868	0.0000	0.0005	0.1	1:30
CORBIN_S_PIER_A	CORBIN_N_PIER_A	-0.0034	-0.0000	0.0004	0.0	1:31
CORBIN_CORS_ARP	CORBIN_QUAD_CP	-1.7509	0.0000	0.0005	0.1	1:36
CORBIN_QUAD_CP	CORBIN_CORS_ARP	1.7509	0.0002	0.0005	0.4	1:37
CORBIN_QUAD_CP	CORBIN_CORS_ARP	1.7509	-0.0001	0.0005	0.1	1:38
CORBIN_QUAD_CP	CORBIN_S_PIER_A	1.8153	-0.0001	0.0005	0.2	1:39
CORBIN_N_PIER_A	CORBIN_CORS_ARP	-0.0610	-0.0001	0.0003	0.2	1:40
CORBIN_CORS_ARP	CORBIN_N_PIER_A	0.0610	-0.0000	0.0003	0.1	1:41

Elapsed Time = 00:00:00

```
15
41
01 00000001 Top of File
01 00000005 Summary of Files Used and Option Settings
02 00000008 Project Folder and Data Files
02 00000014 Project Option Settings
02 00000022 Instrument Standard Error Settings
03 00000024 Project Default Instrument
01 00000027 Summary of Unadjusted Input Observations
02 00000030 Entered Stations
03 00000032 Fixed Elevations
02 00000035 Differential Level Observations
01 00000053 Adjustment Statistical Summary
01 00000071 Adjusted Elevations and Error Propagation
01 00000082 Adjusted Observations and Residuals
02 00000085 Adjusted Differential Level Observations
01 00000102 End of File
0000142A
STAR*NET
0000B7AE
```

E. AXIS Output Results File

```
axis: Axis and IVP Estimation, Frame Alignment & SINEX Software
      Geoscience Australia
      version 1.07


++++++++++++++++++++++++++++++++++++
  1. SOFTWARE OPTIONS
++++++++++++++++++++++++++++++++++++

ELLIPSOIDAL AE           :         6378137.0000
ELLIPSOIDAL FLAT         :   0.0033528106811823
REFERENCE MARK           :                BLDG_11
CONVERGENCE LIMIT        :            0.0000050
MAXIMUM ITERATIONS       :                   18
TIME STAMP (YYYY:MM:DD)  :           2012:03:16
SINEX FILE               :    NGSCORB1204GA.snx
INPUT VCV FILE           :              3D.dmp
INPUT VCV SYSTEM         :               LOCAL
INPUT VCV FORMAT         :             STARNET
COMPUTE ALIGNMENT        :              BEFORE



      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        1.1 APRIORI PARAMETER/CONDITION/CONSTRAINT STANDARD DEVIATIONS
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

NORMAL    PARAMETER NORTH : 0.0000e+00
NORMAL    PARAMETER EAST  : 0.0000e+00
NORMAL    PARAMETER UP    : 0.0000e+00
CENTRE    PARAMETER NORTH : 0.0000e+00 METRE
CENTRE    PARAMETER EAST  : 0.0000e+00 METRE
CENTRE    PARAMETER UP    : 0.0000e+00 METRE
RADIUS    PARAMETER       : 0.0000e+00 METRE
IVP       PARAMETER       : 0.0000e+00 METRE
TOUCH     PARAMETER       : 0.0000e+00 METRE
INTERSECT PARAMETER       : 0.0000e+00 METRE

IVP       CONDITION       : 1.0000e-05 METRE
TOUCH     CONDITION       : 1.0000e-05 METRE
INTERSECT CONDITION       : 1.0000e-05 METRE

UNIT NORMAL CONSTRAINT    : 1.0000e-08

IVP              TIE      : 1.0000e-06 METRE
INTERSECT        TIE      : 1.0000e-05 METRE
CDIST            TIE      : 1.0000e-05 METRE
RADIUS           TIE      : 1.0000e-05 METRE
CENTRE           TIE      : 1.0000e-05 METRE
NORMAL           TIE      : 1.0000e-06 METRE
ORTHOGONAL       TIE      : 1.0000e-06
CENTRE TO CENTRE TIE      : 1.0000e-05 METRE
OFFSET           TIE      : 1.0000e-05 METRE
OANGLE           TIE      : 1.0000e-07
```

```
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        1.2 USER INPUT SINEX INFORMATION
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

SINEX STATIONS           :

        BLDG_11 <<<>>> BL11  A ---------  1 BUILDING 11 DEEP ROD

CORBIN_CORS_INT <<<>>> CORI  A ---------  1 INTERSECTION AT CORB A
CORB_N_PIER_INT <<<>>> CNPI  A ---------  1 INTERSECTION AT CNPA A
 CORBIN_QUAD_CP <<<>>> CQCP  A ---------  1 DISK SET IN CONCRETE

        7550004 <<<>>> 7554  A ---------  1 DISK SET IN CONCRETE

CORBIN_N_PIER_A <<<>>> CNPA  A ---------  1 N RELATIVE PIER ADAPTE
CORBIN_S_PIER_A <<<>>> CSPA  A ---------  1 S RELATIVE PIER ADAPTE
CORBIN_CORS_ARP <<<>>> CORB  A ---------  1 CORB SELF-CENTERING DE


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        1.3 USER INPUT ALIGNMENT STATIONS
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

FRAME                    : GLOBAL (OR REFERENCE SET)
ALIGNMENT STATIONS       : CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES)

        SITE           X(M)           Y(M)          Z(M)

        BLDG_11   1097036.6836  -4897251.7279   3923108.7478
 CORBIN_QUAD_CP   1097038.9281  -4897223.9994   3923141.9723
        7550004   1097071.2913  -4897222.5638   3923134.8720
CORBIN_CORS_ARP   1097041.2148  -4897238.4279   3923126.2779


++++++++++++++++++++++++++++++++++++
  2. INPUT SOLUTION
++++++++++++++++++++++++++++++++++++


      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        2.1 SOLUTION PARAMETER SUMMARY
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


SOLUTION VARIANCE FACTOR :               1.0000
NUMBER OF PARAMETERS     :                   24
NUMBER OF STATIONS       :                    8
NUMBER OF STATION PARA   :                   24
DEGREES OF FREEDOM       :                    0
NUMBER OF AUXILLARY PARA :                    0
VCV REFERENCE SYSTEM     :                LOCAL
CRD REFERENCE SYSTEM     :                LOCAL
```

LOCAL COORDINATES - REFERENCE MARK ORIGIN (METRES)

SITE	EAST	NORTH	UP		SEAST	SNORTH	SUP	TARGET SEQUENCE
BLDG_11	0.0000	-0.0000	66.8850	+/-	0.0001	0.0001	0.0001	
CORBIN_CORS_INT	3.1598	22.1970	68.3074	+/-	0.0005	0.0010	0.0007	
CORB_N_PIER_INT	3.9331	17.1482	68.3684	+/-	0.0006	0.0011	0.0007	
CORBIN_QUAD_CP	0.0000	43.3316	66.5562	+/-	0.0001	0.0003	0.0003	
7550004	33.0418	40.4829	66.6240	+/-	0.0003	0.0004	0.0003	
CORBIN_N_PIER_A	3.9332	17.1474	68.3683	+/-	0.0003	0.0003	0.0003	
CORBIN_S_PIER_A	4.8086	12.2522	68.3717	+/-	0.0003	0.0003	0.0002	
CORBIN_CORS_ARP	3.1597	22.1973	68.3072	+/-	0.0003	0.0003	0.0003	

2.2 SOLUTION VARIANCE COVARIANCE MATRIX REDUCTION

SOLUTION REDUCTION : 24 x 24 >> 24 x 24

VARIANCE-COVARIANCE PARAMETER LIST

1. NORTH BLDG_11
2. EAST BLDG_11
3. HEIGHT BLDG_11
4. NORTH CORBIN_CORS_INT
5. EAST CORBIN_CORS_INT
6. HEIGHT CORBIN_CORS_INT
7. NORTH CORB_N_PIER_INT
8. EAST CORB_N_PIER_INT
9. HEIGHT CORB_N_PIER_INT
10. NORTH CORBIN_QUAD_CP
11. EAST CORBIN_QUAD_CP
12. HEIGHT CORBIN_QUAD_CP
13. NORTH 7550004
14. EAST 7550004
15. HEIGHT 7550004
16. NORTH CORBIN_N_PIER_A
17. EAST CORBIN_N_PIER_A
18. HEIGHT CORBIN_N_PIER_A
19. NORTH CORBIN_S_PIER_A
20. EAST CORBIN_S_PIER_A
21. HEIGHT CORBIN_S_PIER_A
22. NORTH CORBIN_CORS_ARP
23. EAST CORBIN_CORS_ARP
24. HEIGHT CORBIN_CORS_ARP

CORRELATION MATRIX (LEGEND: 1=-0.1|0.1, 2=-0.2|0.2,..., A=-1.0|1.0)

```
  A00000000300200300300300 -- 1.
   A00100100900300300300300 -- 2.
    A0000000030030030040030 -- 3.
     A2000010020000000000 -- 4.
      A000001001000000000 -- 5.
       A000000000000000000 -- 6.
        A40100110000000000 -- 7.
         A0010000000000000 -- 8.
          A000000000000000 -- 9.
           A00500500500500 -- 10.
            A0030030030030 -- 11.
             A006006006007 -- 12.
              A20400410400 -- 13.
               A0030020040 -- 14.
                A005005005 -- 15.
                 A00500500 -- 16.
                  A0040040 -- 17.
                   A007007 -- 18.
                    A00500 -- 19.
                     A0040 -- 20.
                      A006 -- 21.
                       A00 -- 22.
                        A0 -- 23.
                         A -- 24.
```

++++++++++++++++++++++++++++++++++++
  3. APRIORI FRAME ALIGNMENT
++++++++++++++++++++++++++++++++++++

  ++
    3.1 USER INPUT ALIGNMENT STATIONS
  ++

FRAME   : GLOBAL (OR REFERENCE SET)
ALIGNMENT STATIONS   : CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES)

SITE	X(M)	Y(M)	Z(M)
BLDG_11	1097036.6836	-4897251.7279	3923108.7478
CORBIN_QUAD_CP	1097038.9281	-4897223.9994	3923141.9723
7550004	1097071.2913	-4897222.5638	3923134.8720
CORBIN_CORS_ARP	1097041.2148	-4897238.4279	3923126.2779

ALIGN FRAME: VECTOR   BLDG_11 TO CORBIN_QUAD_CP IS (8.2515 42.5391 -0.3303) ENU METRES
INPUT FRAME: VECTOR   BLDG_11 TO CORBIN_QUAD_CP IS (-0.0000 43.3316 -0.3288) ENU METRES

ALIGN FRAME: AZIMUTH   BLDG_11 TO CORBIN_QUAD_CP IS 79.0224 DEGREES
INPUT FRAME: AZIMUTH   BLDG_11 TO CORBIN_QUAD_CP IS 90.0000 DEGREES

ALIGN FRAME: CENTROID IS (1097047.0295 -4897234.1797   3923127.9675) ENU METRES
INPUT FRAME: CENTROID IS (21.8355   -33.7424   60.5843) ENU METRES

```
SOLUTION VARIANCE FACTOR :              1.0000
NUMBER OF PARAMETERS     :                  24
NUMBER OF STATIONS       :                   8
NUMBER OF STATION PARA   :                  24
DEGREES OF FREEDOM       :                   0
NUMBER OF AUXILLARY PARA :                   0
VCV REFERENCE SYSTEM     :               LOCAL
CRD REFERENCE SYSTEM     :          GEOCENTRIC
```

GEODETIC COORDINATES (DMS,DMS,METRES)

SITE	LONGITUDE			LATITUDE			HEIGHT		SEAST	SNORTH	SUP TARGET SEQUENCE
BLDG_11	-77	22	24.8898	38	12	7.1706	34.5064	+/-	0.0001	0.0001	0.0001
CORBIN_CORS_INT	-77	22	24.5886	38	12	7.8579	35.9289	+/-	0.0006	0.0010	0.0007
CORB_N_PIER_INT	-77	22	24.5969	38	12	7.6923	35.9899	+/-	0.0007	0.0011	0.0007
CORBIN_QUAD_CP	-77	22	24.5507	38	12	8.5503	34.1778	+/-	0.0001	0.0003	0.0003
7550004	-77	22	23.2398	38	12	8.2555	34.2456	+/-	0.0003	0.0004	0.0003
CORBIN_N_PIER_A	-77	22	24.5969	38	12	7.6923	35.9897	+/-	0.0003	0.0003	0.0003
CORBIN_S_PIER_A	-77	22	24.5999	38	12	7.5310	35.9932	+/-	0.0003	0.0003	0.0002
CORBIN_CORS_ARP	-77	22	24.5886	38	12	7.8579	35.9287	+/-	0.0003	0.0003	0.0003

LOCAL COORDINATES - REFERENCE MARK ORIGIN (METRES)

SITE	EAST	NORTH	UP		SEAST	SNORTH	SUP TARGET SEQUENCE
BLDG_11	0.0000	0.0000	0.0000	+/-	0.0001	0.0001	0.0001
CORBIN_CORS_INT	7.3288	21.1891	1.4224	+/-	0.0006	0.0010	0.0007
CORB_N_PIER_INT	7.1265	16.0855	1.4834	+/-	0.0007	0.0011	0.0007
CORBIN_QUAD_CP	8.2514	42.5387	-0.3288	+/-	0.0001	0.0003	0.0003
7550004	40.1461	33.4502	-0.2610	+/-	0.0003	0.0004	0.0003
CORBIN_N_PIER_A	7.1265	16.0847	1.4833	+/-	0.0003	0.0003	0.0003
CORBIN_S_PIER_A	7.0537	11.1123	1.4867	+/-	0.0003	0.0003	0.0002
CORBIN_CORS_ARP	7.3288	21.1895	1.4222	+/-	0.0003	0.0003	0.0003

++++++++++++++++++++++++++++++++++++
  4. GEOCENTRIC VCV TRANSFORMATION
++++++++++++++++++++++++++++++++++++

TRANSFORM VARIANCE-COVARIANCE MATRIX Q(NEH) TO Q(XYZ)

CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES)

SITE	X	Y	Z		SX	SY	SZ
BLDG_11	1097036.6833	-4897251.7268	3923108.7472	+/-	0.0001	0.0001	0.0001
CORBIN_CORS_INT	1097041.2148	-4897238.4283	3923126.2781	+/-	0.0006	0.0008	0.0009
CORB_N_PIER_INT	1097041.7178	-4897241.5993	3923122.3051	+/-	0.0006	0.0009	0.0010
CORBIN_QUAD_CP	1097038.9281	-4897223.9998	3923141.9723	+/-	0.0001	0.0003	0.0003
7550004	1097071.2917	-4897222.5645	3923134.8722	+/-	0.0003	0.0003	0.0004
CORBIN_N_PIER_A	1097041.7178	-4897241.5996	3923122.3045	+/-	0.0003	0.0003	0.0003
CORBIN_S_PIER_A	1097042.3196	-4897244.6189	3923118.3991	+/-	0.0003	0.0003	0.0003
CORBIN_CORS_ARP	1097041.2147	-4897238.4280	3923126.2782	+/-	0.0003	0.0003	0.0003

++++++++++++++++++++++++++++++++++++
  5. SINEX GENERATION
++++++++++++++++++++++++++++++++++++

REDUCED VARIANCE-COVARIANCE PARAMETER LIST

1.	STAX	BLDG_11
2.	STAY	BLDG_11
3.	STAZ	BLDG_11
4.	STAX	CORBIN_CORS_INT
5.	STAY	CORBIN_CORS_INT
6.	STAZ	CORBIN_CORS_INT
7.	STAX	CORB_N_PIER_INT
8.	STAY	CORB_N_PIER_INT
9.	STAZ	CORB_N_PIER_INT
10.	STAX	CORBIN_QUAD_CP
11.	STAY	CORBIN_QUAD_CP
12.	STAZ	CORBIN_QUAD_CP
13.	STAX	7550004
14.	STAY	7550004
15.	STAZ	7550004
16.	STAX	CORBIN_N_PIER_A
17.	STAY	CORBIN_N_PIER_A
18.	STAZ	CORBIN_N_PIER_A
19.	STAX	CORBIN_S_PIER_A
20.	STAY	CORBIN_S_PIER_A
21.	STAZ	CORBIN_S_PIER_A
22.	STAX	CORBIN_CORS_ARP
23.	STAY	CORBIN_CORS_ARP
24.	STAZ	CORBIN_CORS_ARP

CORRELATION MATRIX

```
 1.000 0.000-0.000 0.170 0.016-0.012 0.160 0.014-0.011 0.893 0.000 0.000 0.310 0.000 0.000 0.346 0.000 0.000 0.331 0.000 0.000 0.352 0.000 0.000
       1.000-0.000 0.023 0.049 0.054 0.022 0.045 0.050-0.000 0.345-0.000-0.000 0.307-0.000-0.000 0.346-0.000-0.000 0.356-0.000-0.000 0.343-0.000
             1.000-0.019 0.056 0.071-0.018 0.051 0.065-0.000 0.000 0.334-0.000 0.000 0.273-0.000 0.000 0.329-0.000 0.000 0.335-0.000 0.000 0.327
                   1.000 0.211 0.347 0.000 0.000 0.000 0.156 0.010-0.004 0.093 0.026 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                         1.000 0.348 0.000 0.000 0.000 0.031 0.095 0.112-0.051 0.125 0.151 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                               1.000 0.000 0.000 0.000 0.009 0.113 0.135-0.078 0.146 0.181 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                                     1.000 0.335 0.463 0.147 0.014 0.002 0.066 0.050 0.039 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                                           1.000 0.449 0.028 0.084 0.098-0.068 0.114 0.142 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                                                 1.000 0.007 0.099 0.118-0.093 0.128 0.164 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
                                                       1.000-0.154 0.310 0.325-0.092 0.151 0.351-0.098 0.172 0.330-0.078 0.157 0.362-0.117 0.187
                                                             1.000 0.188-0.030 0.592 0.090-0.043 0.609 0.077-0.029 0.588 0.107-0.056 0.639 0.051
                                                                   1.000 0.072 0.100 0.540 0.061 0.077 0.585 0.057 0.110 0.572 0.063 0.049 0.605
                                                                         1.000-0.146-0.222 0.356-0.004 0.014 0.297-0.008 0.009 0.411 0.002 0.016
                                                                               1.000 0.331 0.043 0.527 0.108 0.094 0.522 0.131-0.009 0.528 0.099
                                                                                     1.000 0.066 0.113 0.476 0.120 0.151 0.467 0.003 0.090 0.484
                                                                                           1.000 0.034-0.015 0.474 0.009 0.020 0.471-0.014 0.030
                                                                                                 1.000 0.242 0.012 0.624 0.091-0.018 0.664 0.040
                                                                                                       1.000 0.022 0.093 0.588 0.027 0.039 0.614
                                                                                                             1.000 0.065-0.029 0.449 0.009 0.019
                                                                                                                   1.000 0.298 0.003 0.598 0.107
                                                                                                                         1.000 0.013 0.104 0.574
                                                                                                                               1.000 0.030-0.005
                                                                                                                                     1.000 0.229
                                                                                                                                           1.000
```

```
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
        5.1 USER INPUT SINEX INFORMATION
      ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

SINEX STATIONS           :

        BLDG_11 <<<>>> BL11  A ---------  1 BUILDING 11 DEEP ROD

CORBIN_CORS_INT <<<>>> CORI  A ---------  1 INTERSECTION AT CORB A
CORB_N_PIER_INT <<<>>> CNPI  A ---------  1 INTERSECTION AT CNPA A
 CORBIN_QUAD_CP <<<>>> CQCP  A ---------  1 DISK SET IN CONCRETE

        7550004 <<<>>> 7554  A ---------  1 DISK SET IN CONCRETE

CORBIN_N_PIER_A <<<>>> CNPA  A ---------  1 N RELATIVE PIER ADAPTE
CORBIN_S_PIER_A <<<>>> CSPA  A ---------  1 S RELATIVE PIER ADAPTE
CORBIN_CORS_ARP <<<>>> CORB  A ---------  1 CORB SELF-CENTERING DE

CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES) - VARIANCE-COVARIANCE

        SITE          X              Y              Z        SX       SY       SZ

        BLDG_11   1097036.6833  -4897251.7268   3923108.7472   0.0001   0.0001   0.0001
CORBIN_CORS_INT   1097041.2148  -4897238.4283   3923126.2781   0.0006   0.0008   0.0009
CORB_N_PIER_INT   1097041.7178  -4897241.5993   3923122.3051   0.0006   0.0009   0.0010
 CORBIN_QUAD_CP   1097038.9281  -4897223.9998   3923141.9723   0.0001   0.0003   0.0003
        7550004   1097071.2917  -4897222.5645   3923134.8722   0.0003   0.0003   0.0004
CORBIN_N_PIER_A   1097041.7178  -4897241.5996   3923122.3045   0.0003   0.0003   0.0003
CORBIN_S_PIER_A   1097042.3196  -4897244.6189   3923118.3991   0.0003   0.0003   0.0003
CORBIN_CORS_ARP   1097041.2147  -4897238.4280   3923126.2782   0.0003   0.0003   0.0003

SOLUTION VARIANCE FACTOR :              1.0000

CARTESIAN COORDINATES - EARTH CENTRE ORIGIN (METRES) - COFACTOR

        SITE          X              Y              Z        SX       SY       SZ

        BLDG_11   1097036.6833  -4897251.7268   3923108.7472   0.0001   0.0001   0.0001
CORBIN_CORS_INT   1097041.2148  -4897238.4283   3923126.2781   0.0006   0.0008   0.0009
CORB_N_PIER_INT   1097041.7178  -4897241.5993   3923122.3051   0.0006   0.0009   0.0010
 CORBIN_QUAD_CP   1097038.9281  -4897223.9998   3923141.9723   0.0001   0.0003   0.0003
        7550004   1097071.2917  -4897222.5645   3923134.8722   0.0003   0.0003   0.0004
CORBIN_N_PIER_A   1097041.7178  -4897241.5996   3923122.3045   0.0003   0.0003   0.0003
CORBIN_S_PIER_A   1097042.3196  -4897244.6189   3923118.3991   0.0003   0.0003   0.0003
CORBIN_CORS_ARP   1097041.2147  -4897238.4280   3923126.2782   0.0003   0.0003   0.0003

 WARNING: sinex output request is without apriori data

Normal Termination
```

F. SINEX File NGSCORB1202GA.SNX

```
%=SNX 1.00 AUS 12:137:26837 AUS 12:076:00000 12:077:00000 C 00024 2 X
+FILE/REFERENCE
 DESCRIPTION        Terrestrial Survey Tie
 OUTPUT             SSC SINEX
 CONTACT            _____________________________________________________
 SOFTWARE           axis version 1.07
 HARDWARE           _____________________________________________________
 INPUT              Terrestrial Survey Solution
-FILE/REFERENCE
+FILE/COMMENT
* axis software by John Dawson Geoscience Australia
-FILE/COMMENT
+SITE/ID
 BL11  A --------- C BUILDING 11 DEEP ROD
  -77 22 24.9  38 12  7.2    34.5
 CORI  A --------- C INTERSECTION AT CORB A -77 22 24.6  38 12  7.9    35.9
 CNPI  A --------- C INTERSECTION AT CNPA A -77 22 24.6  38 12  7.7    36.0
 CQCP  A --------- C DISK SET IN CONCRETE
  -77 22 24.6  38 12  8.6    34.2
 7554  A --------- C DISK SET IN CONCRETE
  -77 22 23.2  38 12  8.3    34.2
 CNPA  A --------- C N RELATIVE PIER ADAPTE -77 22 24.6  38 12  7.7    36.0
 CSPA  A --------- C S RELATIVE PIER ADAPTE -77 22 24.6  38 12  7.5    36.0
 CORB  A --------- C CORB SELF-CENTERING DE -77 22 24.6  38 12  7.9    35.9
-SITE/ID
+SITE/DATA
 BL11  A    1 BL11  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CORI  A    1 CORI  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CNPI  A    1 CNPI  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CQCP  A    1 CQCP  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 7554  A    1 7554  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CNPA  A    1 CNPA  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CSPA  A    1 CSPA  A    1 12:076:00000 12:077:00000 --- 12:076:43200
 CORB  A    1 CORB  A    1 12:076:00000 12:077:00000 --- 12:076:43200
-SITE/DATA
+SOLUTION/EPOCHS
 BL11  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CORI  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CNPI  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CQCP  A    1 C 12:076:00000 12:077:00000 12:076:43200
 7554  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CNPA  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CSPA  A    1 C 12:076:00000 12:077:00000 12:076:43200
 CORB  A    1 C 12:076:00000 12:077:00000 12:076:43200
-SOLUTION/EPOCHS
+SOLUTION/STATISTICS
 VARIANCE FACTOR               1.000000000000000e+00
 SQUARE SUM OF RESIDUALS       0.000000000000000e+00
 NUMBER OF OBSERVATIONS                           24
 NUMBER OF UNKNOWNS                               24
-SOLUTION/STATISTICS
+SOLUTION/ESTIMATE
```

```
     1 STAX   BL11  A    1 12:076:43200 m    2  1.09703668342792e+06 1.00000e-04
     2 STAY   BL11  A    1 12:076:43200 m    2 -4.89725172681260e+06 1.00000e-04
     3 STAZ   BL11  A    1 12:076:43200 m    2  3.92310874721335e+06 1.00000e-04
     4 STAX   CORI  A    1 12:076:43200 m    2  1.09704121484413e+06 5.69345e-04
     5 STAY   CORI  A    1 12:076:43200 m    2 -4.89723842832799e+06 8.49025e-04
     6 STAZ   CORI  A    1 12:076:43200 m    2  3.92312627803910e+06 8.72835e-04
     7 STAX   CNPI  A    1 12:076:43200 m    2  1.09704171786054e+06 6.04703e-04
     8 STAY   CNPI  A    1 12:076:43200 m    2 -4.89724159927727e+06 9.21184e-04
     9 STAZ   CNPI  A    1 12:076:43200 m    2  3.92312230512998e+06 9.50327e-04
    10 STAX   CQCP  A    1 12:076:43200 m    2  1.09703892807181e+06 1.11943e-04
    11 STAY   CQCP  A    1 12:076:43200 m    2 -4.89722399979001e+06 2.90270e-04
    12 STAZ   CQCP  A    1 12:076:43200 m    2  3.92314197233248e+06 2.99559e-04
    13 STAX   7554  A    1 12:076:43200 m    2  1.09707129175261e+06 3.22219e-04
    14 STAY   7554  A    1 12:076:43200 m    2 -4.89722256443377e+06 3.25678e-04
    15 STAZ   7554  A    1 12:076:43200 m    2  3.92313487222456e+06 3.66255e-04
    16 STAX   CNPA  A    1 12:076:43200 m    2  1.09704171788956e+06 2.88914e-04
    17 STAY   CNPA  A    1 12:076:43200 m    2 -4.89724159962778e+06 2.89046e-04
    18 STAZ   CNPA  A    1 12:076:43200 m    2  3.92312230444761e+06 3.04292e-04
    19 STAX   CSPA  A    1 12:076:43200 m    2  1.09704231966304e+06 3.02241e-04
    20 STAY   CSPA  A    1 12:076:43200 m    2 -4.89724461893431e+06 2.80512e-04
    21 STAZ   CSPA  A    1 12:076:43200 m    2  3.92311839909757e+06 2.98449e-04
    22 STAX   CORB  A    1 12:076:43200 m    2  1.09704121474766e+06 2.84066e-04
    23 STAY   CORB  A    1 12:076:43200 m    2 -4.89723842796361e+06 2.91751e-04
    24 STAZ   CORB  A    1 12:076:43200 m    2  3.92312627822962e+06 3.05938e-04
-SOLUTION/ESTIMATE
+SOLUTION/MATRIX_ESTIMATE U COVA
     1     1  1.00000000000001e-08  6.75406298743402e-24 -1.03616690574163e-23
     1     4  9.70492104263697e-09  1.31725956155565e-09 -1.06233550696161e-09
     1     7  9.70492090938420e-09  1.31726000223069e-09 -1.06233617786437e-09
     1    10  9.99999999997587e-09  1.64414989319877e-14  1.46208265544595e-14
     1    13  9.99999999967351e-09  7.99945520801532e-14  1.14970462760075e-14
     1    16  9.99999999998848e-09  1.42000310331065e-14  5.52841602726420e-15
     1    19  9.99999999998948e-09  1.40549992840729e-14  3.81937000459552e-15
     1    22  9.99999999998677e-09  1.46032052542000e-14  7.28296442735116e-15
     2     2  1.00000000000000e-08  9.02305414279035e-25  1.31723937312145e-09
     2     5  4.11972248121371e-09  4.74234314541392e-09  1.31724037107591e-09
     2     8  4.11971871453293e-09  4.74234614037276e-09 -1.64414034905834e-14
     2    11  9.99999999977349e-09 -6.52684356256533e-14 -7.99944930580102e-14
     2    14  9.99999999954834e-09 -5.13236527395094e-14 -1.42000173733925e-14
     2    17  9.99999999995947e-09 -2.46792522149427e-14 -1.40549927567275e-14
     2    20  9.99999999997559e-09 -1.70499461852964e-14 -1.46031815603394e-14
     2    23  9.99999999993649e-09 -3.25116841787919e-14
     3     3  1.00000000000000e-08 -1.06234971518997e-09  4.74237410514313e-09
     3     6  6.17535647607916e-09 -1.06234844076138e-09  4.74236931223549e-09
     3     9  6.17536037603703e-09 -1.46209338869400e-14  6.52684115744003e-14
     3    12  9.99999999977632e-09 -1.14974568574051e-14  5.13235607569332e-14
     3    15  9.99999999986169e-09 -5.52845109553235e-15  2.46792443516742e-14
     3    18  9.99999999996802e-09 -3.81939399245523e-15  1.70499408068817e-14
     3    21  9.99999999998474e-09 -7.28301192891344e-15  3.25116735328199e-14
     3    24  9.99999999994450e-09
     4     4  3.24153346412617e-07  1.02021482177973e-07  1.72566842285816e-07
     4     7  0.00000000000000e+00  0.00000000000000e+00  0.00000000000000e+00
     4    10  9.95566137591155e-09  1.73010347366026e-09 -6.13747640067521e-10
     4    13  1.71390890276727e-08  4.75186954401953e-09  1.14938565427116e-09
     4    16  0.00000000000000e+00  0.00000000000000e+00  0.00000000000000e+00
     4    19  0.00000000000000e+00  0.00000000000000e+00  0.00000000000000e+00
     4    22  0.00000000000000e+00  0.00000000000000e+00  0.00000000000000e+00
     5     5  7.20842855567908e-07  2.57894342301709e-07  0.00000000000000e+00
     5     8  0.00000000000000e+00  0.00000000000000e+00  2.95033783878839e-09
     5    11  2.35017457703098e-08  2.83745079452652e-08 -1.39110181778336e-08
     5    14  3.46312375524755e-08  4.68644950961698e-08  0.00000000000000e+00
```

5	17	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
5	20	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
5	23	0.00000000000000e+00	0.00000000000000e+00	
6	6	7.61841801964498e-07	0.00000000000000e+00	0.00000000000000e+00
6	9	0.00000000000000e+00	8.92942912655513e-10	2.86602773521621e-08
6	12	3.53532606520790e-08	-2.20094712410147e-08	4.16208843140688e-08
6	15	5.77900664070347e-08	0.00000000000000e+00	0.00000000000000e+00
6	18	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
6	21	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
6	24	0.00000000000000e+00		
7	7	3.65665298351048e-07	1.86680109575222e-07	2.66008723584818e-07
7	10	9.97292199259569e-09	2.52402658477728e-09	3.69398492180678e-10
7	13	1.27860029809704e-08	9.76087524140564e-09	8.57503294713598e-09
7	16	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
7	19	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
7	22	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
8	8	8.48579461818386e-07	3.92766179907282e-07	2.85677420016108e-09
8	11	2.25107572936416e-08	2.71669381156361e-08	-2.02087337589536e-08
8	14	3.41248832873634e-08	4.79754478563072e-08	0.00000000000000e+00
8	17	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
8	20	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
8	23	0.00000000000000e+00	0.00000000000000e+00	
9	9	9.03121302441158e-07	7.72136747929890e-10	2.72110309705389e-08
9	12	3.35829170577519e-08	-2.86092051689459e-08	3.96017861379878e-08
9	15	5.71051141035065e-08	0.00000000000000e+00	0.00000000000000e+00
9	18	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
9	21	0.00000000000000e+00	0.00000000000000e+00	0.00000000000000e+00
9	24	0.00000000000000e+00		
10	10	1.25312669962653e-08	-4.99840086881000e-09	1.04093388822321e-08
10	13	1.17309000774042e-08	-3.35837769849048e-09	6.19089884560520e-09
10	16	1.13434051294165e-08	-3.15815104454757e-09	5.84821198762234e-09
10	19	1.11636306674157e-08	-2.44722921740798e-09	5.25455592079638e-09
10	22	1.15142078561456e-08	-3.82134128276449e-09	6.39511887350832e-09
11	11	8.42565563788057e-08	1.63113358461937e-08	-2.78460897700993e-09
11	14	5.60063634894105e-08	9.55692404049782e-09	-3.62631478919380e-09
11	17	5.11330036996743e-08	6.82033521802820e-09	-2.54396689827556e-09
11	20	4.78970810166248e-08	9.30259389749490e-09	-4.64647363357200e-09
11	23	5.41112747515412e-08	4.48702900369913e-09	
12	12	8.97356640068294e-08	6.93272003356165e-09	9.71932247241838e-09
12	15	5.92111086856163e-08	5.28187319560636e-09	6.69185036405616e-09
12	18	5.33693984202054e-08	5.15196502646415e-09	9.28078286105175e-09
12	21	5.11164145215137e-08	5.38424372845724e-09	4.24841912897012e-09
12	24	5.54212113815241e-08		
13	13	1.03824831653697e-07	-1.53610564777229e-08	-2.61762240590807e-08
13	16	3.31623121645397e-08	-4.09782536857826e-10	1.40641754222477e-09
13	19	2.88856223804632e-08	-7.43923051571921e-10	8.81435768896861e-10
13	22	3.75935704266783e-08	2.24200095617822e-10	1.61471286429160e-09
14	14	1.06066032657228e-07	3.95126829405005e-08	4.06027846111398e-09
14	17	4.95828650055095e-08	1.07238555620946e-08	9.22632588199213e-09
14	20	4.77142884147674e-08	1.27597535405734e-08	-8.40535221360670e-10
14	23	5.01214869989532e-08	9.88034003208621e-09	
15	15	1.34142881211806e-07	6.95483706392066e-09	1.19615923574198e-08
15	18	5.30151726765461e-08	1.32513885576368e-08	1.55272838739342e-08
15	21	5.10051892247736e-08	2.93071891354926e-10	9.57392347226759e-09
15	24	5.42372452416902e-08		
16	16	8.34714550880514e-08	2.87705301226101e-09	-1.32366071489505e-09
16	19	4.13990208533107e-08	7.50956702971163e-10	1.69337965141418e-09
16	22	3.86866335738658e-08	-1.16032102490530e-09	2.68698690018535e-09
17	17	8.35478559014481e-08	2.13069840550427e-08	1.00668061921233e-09
17	20	5.06026315425506e-08	7.84783238621120e-09	-1.44357825209759e-09
17	23	5.59690360588270e-08	3.55734360248330e-09	

```
    18    18  9.25936635734826e-08  2.01384735830237e-09  7.92518761361955e-09
    18    21  5.33855859847914e-08  2.33242457938507e-09  3.47068592072718e-09
    18    24  5.71747444071022e-08
    19    19  9.13493838601681e-08  5.50291677951956e-09 -2.57950792674483e-09
    19    22  3.85505006547973e-08  7.58665109570619e-10  1.78308117225514e-09
    20    20  7.86868128727917e-08  2.49318743169858e-08  2.04917828547545e-10
    20    23  4.89341671159603e-08  9.18832897108385e-09
    21    21  8.90716463110999e-08  1.09000171660767e-09  9.02825186879755e-09
    21    24  5.24523513099305e-08
    22    22  8.06935145024600e-08  2.44931729151626e-09 -4.24869825261082e-10
    23    23  8.51185065879145e-08  2.04099675592224e-08
    24    24  9.35978080009081e-08
-SOLUTION/MATRIX_ESTIMATE U COVA
%ENDSNX
```

G. GPS Geocentric Coordinates and Covariances (network-final.snx)

Adjustment performed in IGS08 (2012.076) reference frame

```
%=SNX 1.00 NOA 12:123:52801 NOA 12:037:00000 12:116:86370 P    30 2 X - -
*------------------------------------------------------------------------------
+FILE/REFERENCE
 DESCRIPTION    OPUS-Projects : NOAA/NOS/NGS
 OUTPUT         network-final
 CONTACT        charles.geoghegan@noaa.gov
 SOFTWARE       pages.e & gpscom.e
 HARDWARE       fermi (SunOS i86pc)
 INPUT          Foundation CORS Site Survey Test (corb) GNSS data
-FILE/REFERENCE
*------------------------------------------------------------------------------
+FILE/COMMENT
 This combined adjustment was made from internal NGS files
 of partially reduced normal equations (information matricies).
 The data sets included in this solution are shown below.
     ../12037/Results/2012-037-A.nrm                                  0
     ../12116/Results/2012-116-A.nrm                                  0
-FILE/COMMENT
*------------------------------------------------------------------------------
+SOLUTION/STATISTICS
 NUMBER OF OBSERVATIONS                          295105.
 NUMBER OF UNKNOWNS                                 932
 NUMBER OF CONSTRAINT EQUATIONS                      18
 NUMBER OF DEGREES OF FREEDOM                    294191.
 VARIANCE FACTOR                      0.332333283192122
-SOLUTION/STATISTICS
*------------------------------------------------------------------------------
+SITE/ID
*CODE PT DOMES____ T STATION DESCRIPTION___ APPROX_LON_ APPROX_LAT_ _APP_H_
 7554  - --------- P 7554                   282 37 36.8  38 12  8.3    34.3
 bl11  - --------- P bl11                   282 37 35.1  38 12  7.2    34.5
 corb  - --------- P corb                   282 37 35.4  38 12  7.9    34.6
 cqcp  - --------- P cqcp                   282 37 35.5  38 12  8.5    34.2
 LOY8  A --------- P LOYOLA 8 COOP          282 32 50.5  38 16 58.7    -6.2
 LOYB  A --------- P LOYOLA B COOP          282 48 57.7  38 43 42.0    -2.8
 LOYJ  A --------- P LOYOLA J               281 59 23.8  38 28 20.9   103.9
 LOYM  A --------- P LOYOLA M               283 22  2.0  38 18 38.1     4.8
 LOYO  A --------- P LOYOLA O               282 39  8.8  38  3  0.7    41.9
 LOY3  A --------- P LOYOLA 3 COOP          282 29 44.1  37 37 22.6    35.3
-SITE/ID
*------------------------------------------------------------------------------
```

```
+SITE/RECEIVER
*SITE PT SOLN T DATA_START__ DATA_END____ DESCRIPTION_________ S/N__ FIRMWARE___
 7554  -    1 P 12:037:00000 12:116:86399 ----------------     ----- -----------
 bl11  -    1 P 12:037:00000 12:116:86399 ----------------     ----- -----------
 corb  -    1 P 12:037:00000 12:116:86399 ----------------     ----- -----------
 cqcp  -    1 P 12:037:00000 12:116:86399 ----------------     ----- -----------
 LOY8  A    3 P 12:037:00000 12:116:86399 LEICA SR530          33102 5.06/1.39
 LOYB  A    3 P 12:037:00000 12:116:86399 LEICA GRX1200GGPRO   35110 6.02/1.39
 LOYJ  A    3 P 12:037:00000 12:116:86399 LEICA GRX1200GGPRO   35043 6.02/3.015
 LOYM  A    3 P 12:037:00000 12:116:86399 LEICA GRX1200GGPRO   35011 6.02/3.015
 LOYO  A    3 P 12:037:00000 12:116:86399 LEICA GRX1200GGPRO   35110 6.02/3.15
 LOY3  A    2 P 12:116:00000 12:116:86399 LEICA GR10           17000 2.00.642/6.
-SITE/RECEIVER
*------------------------------------------------------------------------------
+SITE/ANTENNA
*SITE PT SOLN T DATA_START__ DATA_END____ DESCRIPTION_________ S/N__
 7554  -    1 P 12:037:00000 12:116:86399 ----------------     -----
 bl11  -    1 P 12:037:00000 12:116:86399 ----------------     -----
 corb  -    1 P 12:037:00000 12:116:86399 ----------------     -----
 cqcp  -    1 P 12:037:00000 12:116:86399 ----------------     -----
 LOY8  A    3 P 12:037:00000 12:116:86399 LEIAX1202       NONE 44801
 LOYB  A    3 P 12:037:00000 12:116:86399 LEIAX1202GG     NONE 07110
 LOYJ  A    3 P 12:037:00000 12:116:86399 LEIAX1202GG     NONE 06180
 LOYM  A    3 P 12:037:00000 12:116:86399 LEIAX1202GG     NONE 06100
 LOYO  A    3 P 12:037:00000 12:116:86399 LEIAX1202GG     NONE 06180
 LOY3  A    2 P 12:116:00000 12:116:86399 LEIAR10         NONE 13167
-SITE/ANTENNA
*------------------------------------------------------------------------------
+SITE/GPS_PHASE_CENTER
* Antenna information is from the file
*     /home/OPUS/files/ngs08.atx
* abbreviated below as  ant.info
*                            UP___  NORTH EAST_  UP___  NORTH  EAST_
*DESCRIPTION_________ S/N__ L1->ARP(m)__________ __L2->ARP(m)________ AZ_EL
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 ----------------     ----- 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000   ant.info
 LEIAX1202       NONE 44801 0.0643 0.0014 -.0001 0.0629 -.0003 0.0000   ant.info
 LEIAX1202GG     NONE 07110 0.0634 0.0016 -.0005 0.0621 -.0012 0.0002   ant.info
 LEIAX1202GG     NONE 06180 0.0634 0.0016 -.0005 0.0621 -.0012 0.0002   ant.info
 LEIAX1202GG     NONE 06100 0.0634 0.0016 -.0005 0.0621 -.0012 0.0002   ant.info
 LEIAX1202GG     NONE 06180 0.0634 0.0016 -.0005 0.0621 -.0012 0.0002   ant.info
 LEIAR10         NONE 13167 0.0888 0.0013 -.0007 0.0818 0.0005 0.0001   ant.info
-SITE/GPS_PHASE_CENTER
*------------------------------------------------------------------------------
```

```
+SITE/ECCENTRICITY
*SITE PT SOLN T DATA_START__ DATA_END____ AXE ARP->BENCHMARK(m)_________
 7554  -    1 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 bl11  -    1 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 corb  -    1 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 cqcp  -    1 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOY8  A    3 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOYB  A    3 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOYJ  A    3 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOYM  A    3 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOYO  A    3 P 12:037:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
 LOY3  A    2 P 12:116:00000 12:116:86399 UNE   0.0000   0.0000   0.0000
-SITE/ECCENTRICITY
*--------------------------------------------------------------------------------
+SOLUTION/EPOCHS
*SITE PT SOLN T _DATA_START_ __DATA_END__ _MEAN_EPOCH_
 7554  -    1 P 12:037:00000 12:116:86399 12:063:21716
 bl11  -    1 P 12:037:00000 12:116:86399 12:063:85921
 corb  -    1 P 12:037:00000 12:116:86399 12:063:02152
 cqcp  -    1 P 12:037:00000 12:116:86399 12:063:51410
 LOY8  A    3 P 12:037:00000 12:116:86399 12:063:82848
 LOYB  A    3 P 12:037:00000 12:116:86399 12:063:73886
 LOYJ  A    3 P 12:037:00000 12:116:86399 12:064:03354
 LOYM  A    3 P 12:037:00000 12:116:86399 12:063:83134
 LOYO  A    3 P 12:037:00000 12:116:86399 12:087:22185
 LOY3  A    2 P 12:116:00000 12:116:86399 12:116:43854
-SOLUTION/EPOCHS
*--------------------------------------------------------------------------------
```

```
+SOLUTION/ESTIMATE
*INDEX TYPE   CODE PT SOLN _REF_EPOCH__ UNIT S  __ESTIMATED VALUE___ _STD_DEV___
     1 STAX   7554  -    1 12:076:86385 m    2 0.109707129135110E+07 .123053E-03
     2 STAY   7554  -    1 12:076:86385 m    2 -.489722256378186E+07 .393693E-03
     3 STAZ   7554  -    1 12:076:86385 m    2 0.392313487200748E+07 .311510E-03
     4 STAX   bl11  -    1 12:076:86385 m    2 0.109703668365104E+07 .120247E-03
     5 STAY   bl11  -    1 12:076:86385 m    2 -.489725172793466E+07 .385672E-03
     6 STAZ   bl11  -    1 12:076:86385 m    2 0.392310874778769E+07 .302478E-03
     7 STAX   corb  -    1 12:076:86385 m    2 0.109704121478941E+07 .121827E-03
     8 STAY   corb  -    1 12:076:86385 m    2 -.489723842785120E+07 .386760E-03
     9 STAZ   corb  -    1 12:076:86385 m    2 0.392312627793290E+07 .303669E-03
    10 STAX   cqcp  -    1 12:076:86385 m    2 0.109703892813019E+07 .119253E-03
    11 STAY   cqcp  -    1 12:076:86385 m    2 -.489722399937095E+07 .379013E-03
    12 STAZ   cqcp  -    1 12:076:86385 m    2 0.392314197232331E+07 .297594E-03
    13 STAX   LOY8  A    3 12:076:86385 m    0 0.108906277651038E+07 .294117E-04
    14 STAY   LOY8  A    3 12:076:86385 m    0 -.489329793834082E+07 .318818E-04
    15 STAZ   LOY8  A    3 12:076:86385 m    0 0.393014395491899E+07 .312900E-04
    16 STAX   LOYB  A    3 12:076:86385 m    0 0.110516817673132E+07 .297456E-04
    17 STAY   LOYB  A    3 12:076:86385 m    0 -.485812688434433E+07 .320950E-04
    18 STAZ   LOYB  A    3 12:076:86385 m    0 0.396883402929099E+07 .315112E-04
    19 STAX   LOYJ  A    3 12:076:86385 m    0 0.103871168458965E+07 .303826E-04
    20 STAY   LOYJ  A    3 12:076:86385 m    0 -.489097095409787E+07 .319190E-04
    21 STAZ   LOYJ  A    3 12:076:86385 m    0 0.394670265469401E+07 .312498E-04
    22 STAX   LOYM  A    3 12:076:86385 m    0 0.115853107623403E+07 .316203E-04
    23 STAY   LOYM  A    3 12:076:86385 m    0 -.487537376039069E+07 .325451E-04
    24 STAZ   LOYM  A    3 12:076:86385 m    0 0.393255680360875E+07 .322470E-04
    25 STAX   LOYO  A    3 12:076:86385 m    0 0.110154124068564E+07 .306396E-04
    26 STAY   LOYO  A    3 12:076:86385 m    0 -.490690948021901E+07 .324536E-04
    27 STAZ   LOYO  A    3 12:076:86385 m    0 0.390985755584297E+07 .320880E-04
    28 STAX   LOY3  A    2 12:076:86385 m    0 0.109439432542401E+07 .318952E-04
    29 STAY   LOY3  A    2 12:076:86385 m    0 -.493830156329003E+07 .329488E-04
    30 STAZ   LOY3  A    2 12:076:86385 m    0 0.387240217688662E+07 .327932E-04
-SOLUTION/ESTIMATE
*------------------------------------------------------------------------------
```

```
+SOLUTION/APRIORI
*INDEX TYPE   CODE PT SOLN _REF_EPOCH__ UNIT S  __A-PRIORI VALUE____ _STD_DEV___
    13 STAX   LOY8  A    3 12:076:86385 m    0 0.108906288300274E+07 .518656E+13
    14 STAY   LOY8  A    3 12:076:86385 m    0 -.489329793200068E+07 .518656E+13
    15 STAZ   LOY8  A    3 12:076:86385 m    0 0.393014393400081E+07 .518656E+13
    16 STAX   LOYB  A    3 12:076:86385 m    0 0.110516828300317E+07 .518656E+13
    17 STAY   LOYB  A    3 12:076:86385 m    0 -.485812687799788E+07 .518656E+13
    18 STAZ   LOYB  A    3 12:076:86385 m    0 0.396883400799809E+07 .518656E+13
    19 STAX   LOYJ  A    3 12:076:86385 m    0 0.103871179000048E+07 .518656E+13
    20 STAY   LOYJ  A    3 12:076:86385 m    0 -.489097094800375E+07 .518656E+13
    21 STAZ   LOYJ  A    3 12:076:86385 m    0 0.394670263499998E+07 .518656E+13
    22 STAX   LOYM  A    3 12:076:86385 m    0 0.115853118200365E+07 .518656E+13
    23 STAY   LOYM  A    3 12:076:86385 m    0 -.487537375399726E+07 .518656E+13
    24 STAZ   LOYM  A    3 12:076:86385 m    0 0.393255678099849E+07 .518656E+13
    25 STAX   LOYO  A    3 12:076:86385 m    0 0.110154134499812E+07 .518656E+13
    26 STAY   LOYO  A    3 12:076:86385 m    0 -.490690947399937E+07 .518656E+13
    27 STAZ   LOYO  A    3 12:076:86385 m    0 0.390985753499862E+07 .518656E+13
    28 STAX   LOY3  A    2 12:076:86385 m    0 0.109439442999943E+07 .518656E+13
    29 STAY   LOY3  A    2 12:076:86385 m    0 -.493830155699670E+07 .518656E+13
    30 STAZ   LOY3  A    2 12:076:86385 m    0 0.387240215599721E+07 .518656E+13
-SOLUTION/APRIORI
*------------------------------------------------------------------------------
+SOLUTION/MATRIX_ESTIMATE U COVA
     1     1 0.151420810908406E-07 -.349502979978316E-07 0.256281247122527E-07
     1     4 0.251138277754394E-08 -.550750765441164E-08 0.399700316084092E-08
     1     7 0.261457395551673E-08 -.578822416455682E-08 0.419836482506002E-08
     1    10 0.246580358499298E-08 -.534533632623594E-08 0.388634525423407E-08
     1    13 0.205725878881870E-09 0.921458801577630E-12 0.326600384117356E-11
     1    16 0.197669293228982E-09 0.113593001307656E-11 -.159853110564179E-11
     1    19 0.211072364138177E-09 0.294069297125374E-11 0.347851663531509E-11
     1    22 0.220155455019188E-09 -.144921073020867E-10 -.171396317570759E-10
     1    25 0.201557488132506E-09 -.206314266883357E-11 0.216545739695426E-11
     1    28 0.717841261283760E-10 0.115011211053111E-10 0.978567106292688E-11
     2     2 0.154994418723363E-06 -.112999587040085E-06 -.549820223513668E-08
     2     5 0.251719715552533E-07 -.180315819361812E-07 -.577180323016544E-08
     2     8 0.264116106937878E-07 -.189464579312469E-07 -.535156919706543E-08
     2    11 0.243996057665552E-07 -.174589981957693E-07 0.685630882520960E-12
     2    14 0.205302669128538E-09 -.682233719973026E-11 -.370132918163381E-11
     2    17 0.171383276407362E-09 -.238417948055136E-10 0.195718458137461E-10
     2    20 0.191111825541856E-09 -.119461176228320E-10 -.359387469608280E-10
     2    23 0.266600762366411E-09 0.484479075189927E-10 -.940109033170573E-12
     2    26 0.222953341024486E-09 0.612275255916280E-11 0.206898222079299E-10
     2    29 0.507509022600023E-10 -.115127216766932E-10
     3     3 0.970381779849503E-07 0.399203733292022E-08 -.180629663761996E-07
     3     6 0.156170507789379E-07 0.418585176139083E-08 -.189802987728535E-07
     3     9 0.163434292682948E-07 0.388493666637721E-08 -.174998216970985E-07
     3    12 0.151823915389897E-07 0.734970530159394E-11 0.770402634470084E-11
     3    15 0.219574490985672E-09 -.814184627578966E-11 -.770366925749370E-12
     3    18 0.190740811056358E-09 0.389160427309818E-10 0.159749390083368E-10
     3    21 0.207167727407835E-09 -.294078510424593E-10 -.456769307862258E-10
     3    24 0.179390637442727E-09 -.108126844967752E-11 0.609690075329057E-11
     3    27 0.228625706252802E-09 -.775632900027839E-11 0.162326778139702E-10
     3    30 0.821867658748269E-10
```

```
 4     4 0.144593942967935E-07 -.328685581349208E-07 0.237658942483969E-07
 4     7 0.266665638753680E-08 -.594051192511114E-08 0.430958186849070E-08
 4    10 0.247007612472575E-08 -.536363975688739E-08 0.389494592599751E-08
 4    13 0.204250526033862E-09 -.134784848277753E-12 0.301623708871517E-11
 4    16 0.198195260245110E-09 0.224286951649854E-11 0.488980503010481E-12
 4    19 0.204139585582164E-09 0.160840625090394E-11 0.378128230331262E-11
 4    22 0.189452429095533E-09 -.612030454377368E-11 -.116749386027525E-10
 4    25 0.223136189901778E-09 -.614474496502001E-11 -.132057647195438E-12
 4    28 0.888252236605570E-10 0.850203809894197E-11 0.445936174581333E-11
 5     5 0.148743218252298E-06 -.107133632090220E-06 -.594118896890052E-08
 5     8 0.267389389933492E-07 -.191828159039866E-07 -.537114889060798E-08
 5    11 0.243586783752818E-07 -.174458362173905E-07 0.194527380825135E-11
 5    14 0.206549160753361E-09 -.893540929683094E-11 0.205264144014090E-11
 5    17 0.181090364670471E-09 -.169844286790189E-10 0.177229197358315E-10
 5    20 0.192436115435697E-09 -.122166521498756E-10 0.980799053858959E-12
 5    23 0.226765471110454E-09 0.453588762363090E-10 -.262960182963562E-10
 5    26 0.242014965593926E-09 0.376180552074548E-11 0.381819466658690E-11
 5    29 0.591701023427537E-10 -.105276661120652E-10
 6     6 0.914931458904580E-07 0.430602579385679E-08 -.191721445739307E-07
 6     9 0.164952603680865E-07 0.389546341812264E-08 -.174382512849058E-07
 6    12 0.151506129135499E-07 0.639601427145564E-11 0.677506593341542E-11
 6    15 0.220913709685842E-09 -.109328848015200E-10 -.568092813596197E-11
 6    18 0.187445403482017E-09 0.378962107036043E-10 0.146518289328874E-10
 6    21 0.207539315871967E-09 -.486020786479659E-10 -.290908377812252E-10
 6    24 0.162747865302579E-09 0.145762900509516E-10 -.370531586645258E-12
 6    27 0.241358859579222E-09 0.647855239970500E-12 0.133464303068998E-10
 6    30 0.876742098602678E-10
 7     7 0.148418587696622E-07 -.334674664208469E-07 0.241773030153281E-07
 7    10 0.256714320963873E-08 -.559765535708489E-08 0.405791809297052E-08
 7    13 0.211437353324878E-09 -.449507840118468E-12 0.258221562499134E-11
 7    16 0.205500991907028E-09 0.251488140060010E-11 0.412425038537109E-12
 7    19 0.210589608957104E-09 0.134336766795584E-11 0.348422338582519E-11
 7    22 0.197131670152501E-09 -.645649537520369E-11 -.121627941248623E-10
 7    25 0.209682390985625E-09 -.506149613249266E-11 -.136210259876676E-12
 7    28 0.736725498025555E-10 0.806792626738137E-11 0.576314179842387E-11
 8     8 0.149583612138587E-06 -.107852442635387E-06 -.561693460731294E-08
 8    11 0.253663260749883E-07 -.181833793259478E-07 -.455853581580591E-11
 8    14 0.210559407523421E-09 -.958175053495718E-11 -.650338938241218E-11
 8    17 0.182057500136824E-09 -.192202709628392E-10 0.145604545842969E-10
 8    20 0.196207624709776E-09 -.130529540653049E-10 -.936978046779523E-11
 8    23 0.230622208622711E-09 0.445807365561085E-10 -.121120348238238E-10
 8    26 0.233411074608761E-09 0.827257953552177E-11 0.181884016311679E-10
 8    29 0.551785958182590E-10 -.105391074599995E-10
 9     9 0.922147963278348E-07 0.407075912501127E-08 -.181906975891702E-07
 9    12 0.157479007015103E-07 0.104371501994388E-10 0.597187793942987E-11
 9    15 0.224756777904406E-09 -.688776029617835E-11 -.652410091972152E-11
 9    18 0.189816510090240E-09 0.427832480974367E-10 0.140610979284412E-10
 9    21 0.210689005744085E-09 -.457744887772569E-10 -.311132045205391E-10
 9    24 0.165848912476913E-09 0.612988194169337E-11 0.236393136447303E-11
 9    27 0.232067699681289E-09 -.669720095600108E-11 0.148567041713407E-10
 9    30 0.844941807412022E-10
10    10 0.142211955136692E-07 -.320263753821887E-07 0.231413586303381E-07
10    13 0.218472159771052E-09 -.295653761981924E-11 0.154286538571794E-11
```

```
10    16 0.213570303116400E-09 0.310929098832089E-11 0.204168903121067E-11
10    19 0.213262983142444E-09 -.486277529165522E-12 0.337600703199763E-11
10    22 0.193609841840732E-09 -.318958690505844E-11 -.103317980529248E-10
10    25 0.199939560244928E-09 -.321227181758472E-11 -.386882891080977E-12
10    28 0.691913636402634E-10 0.669705468022207E-11 0.369700149739095E-11
11    11 0.143650696175161E-06 -.103375733273455E-06 -.720430231751300E-11
11    14 0.225296539727595E-09 -.845845955862374E-11 -.126913356865268E-10
11    17 0.190421051523589E-09 -.201873368601710E-10 0.156160127572575E-10
11    20 0.206284703795351E-09 -.131652974426768E-10 -.111930352882647E-10
11    23 0.215623494796254E-09 0.426800290566701E-10 -.559369472169401E-11
11    26 0.217859357272983E-09 0.923022814493630E-11 0.211879517624647E-10
11    29 0.525489167460511E-10 -.962713388743487E-11
12    12 0.885624244318847E-07 0.116494946440465E-10 -.633272657281922E-12
12    15 0.229549009995474E-09 -.435005036723927E-11 -.120122876028689E-10
12    18 0.191528077974674E-09 0.452676527912074E-10 0.102186018862143E-10
12    21 0.214656813015156E-09 -.473712180062557E-10 -.253711487789618E-10
12    24 0.161542210463355E-09 0.247237322351471E-11 0.992522378529104E-11
12    27 0.225860666991140E-09 -.762732798470748E-11 0.174968055217820E-10
12    30 0.845220255769741E-10
13    13 0.865050266406483E-09 -.480804945514840E-10 0.732851586718895E-11
13    16 0.906789244237329E-10 0.182432939851525E-10 -.319238273135442E-11
13    19 0.817639933648775E-10 0.131597621092024E-10 -.513134771437558E-11
13    22 0.271666212102437E-10 0.577059477714164E-11 -.699440773288093E-12
13    25 0.314206368025948E-10 0.757297653630884E-11 0.882252055534496E-12
13    28 0.119175578299409E-10 0.334381123526021E-11 0.812442682439123E-12
14    14 0.101644867359411E-08 -.903258550858280E-10 0.826818105203352E-11
14    17 0.272665830755688E-10 0.268490330951634E-10 0.263983669203568E-10
14    20 0.362894657988894E-10 0.343036699988150E-10 0.396266174128487E-11
14    23 0.111303875668164E-10 0.116509228951899E-10 0.645537503693436E-11
14    26 0.126859612102094E-10 0.132514923750343E-10 0.301216624975841E-11
14    29 0.410607062415492E-11 0.428471736647869E-11
15    15 0.979062237413546E-09 -.152546468055895E-10 0.245334325094441E-10
15    18 0.394762859394108E-10 0.109176365982131E-10 0.376562959292942E-10
15    21 0.494004171041868E-10 -.276427725253678E-11 0.111635863528526E-10
15    24 0.159529019958624E-10 -.502700245030197E-12 0.128449460364624E-10
15    27 0.182423462240199E-10 0.290748323895624E-12 0.406332940957074E-11
15    30 0.583912181505751E-11
16    16 0.884800963423482E-09 -.302987928095468E-10 0.255321441948390E-10
16    19 0.540458513024930E-10 0.692887880512953E-11 -.620318783601451E-11
16    22 0.368379173503310E-10 0.902461967837937E-11 0.120693913370919E-12
16    25 0.309324022378796E-10 0.500331203997603E-11 -.243222241565257E-11
16    28 0.106082911675654E-10 0.113523400392680E-11 -.186553374227905E-11
17    17 0.103009101649890E-08 -.772985187249733E-10 -.143990174492020E-10
17    20 0.258218759527703E-10 0.321239058110403E-10 0.180392944610053E-10
17    23 0.154677675256849E-10 0.123615240902707E-10 0.669332299406417E-11
17    26 0.840733124098361E-11 0.774196605264173E-11 0.164150191518821E-11
17    29 0.102039172786595E-11 0.478188825613749E-12
18    18 0.992958765221732E-09 -.333635247872591E-10 0.264217759339351E-10
18    21 0.460413821352597E-10 0.124297522921431E-10 0.155124759368241E-10
18    24 0.163370024844496E-10 -.299611721642701E-12 0.802812603114160E-11
18    27 0.117144737115049E-10 -.116152596616036E-11 0.629982319193666E-12
18    30 0.141867733504488E-11
19    19 0.923104812833036E-09 -.323237415608674E-10 0.920181279831927E-11
```

```
    19    22 0.445585206464558E-11 -.990000064282915E-12 -.176316970232489E-11
    19    25 0.306562039332349E-10 0.133930539433152E-10 0.884524240709157E-11
    19    28 0.139442967223659E-10 0.772588076445531E-11 0.640127477896248E-11
    20    20 0.101882251398988E-08 -.929749002104516E-10 0.291685640363043E-11
    20    23 0.102938606226206E-10 0.112674591906564E-10 0.628257235746870E-11
    20    26 0.124399792090421E-10 0.131593842597704E-10 0.312039934580877E-11
    20    29 0.429576284225845E-11 0.453319452512119E-11
    21    21 0.976550904264076E-09 0.220827382714321E-11 0.122697959778073E-10
    21    24 0.155505037609751E-10 -.992621236963567E-13 0.111806420672276E-10
    21    27 0.158577293756526E-10 0.659574045466027E-13 0.313951911423914E-11
    21    30 0.457953498842910E-11
    22    22 0.999843279699989E-09 -.224476079670933E-10 0.341515389354456E-11
    22    25 0.308052056108660E-10 -.175434608527345E-12 -.940121762369456E-11
    22    28 0.883791852878531E-11 -.216877973048877E-11 -.603793633047004E-11
    23    23 0.105918336373774E-08 -.498097801302459E-10 0.669430313076265E-11
    23    26 0.100989774941566E-10 0.945075533032047E-11 0.188936508393403E-11
    23    29 0.181253041901166E-11 0.136954661652470E-11
    24    24 0.103986992190035E-08 -.791782721828737E-12 0.115779972477631E-10
    24    27 0.160031555234558E-10 -.317489118173436E-12 0.294704629734888E-11
    24    30 0.424385966949014E-11
    25    25 0.938785432648188E-09 -.322309780961279E-10 0.701163070799863E-11
    25    28 0.453877109182132E-10 0.610948834033180E-11 -.532336411807354E-11
    26    26 0.105323926887294E-08 -.539699689382104E-10 0.645259290470462E-11
    26    29 0.110639348143699E-10 0.103402437066383E-10
    27    27 0.102964290146775E-08 -.488903484387948E-11 0.103185623868396E-10
    27    30 0.165064736546249E-10
    28    28 0.101730609063016E-08 -.161229203571131E-10 0.602994600180392E-11
    29    29 0.108562256754391E-08 -.210741030559893E-10
    30    30 0.107539695006857E-08
-SOLUTION/MATRIX_ESTIMATE U COVA
*-------------------------------------------------------------------------------
+SOLUTION/MATRIX_APRIORI U COVA
    13    13 0.110796845856717E-08 -.314453894938599E-26 -.206948289831385E-25
    14    14 0.110796845856717E-08 0.124061468293724E-24
    15    15 0.110796845856717E-08
    16    16 0.110796845856717E-08 -.736413394984411E-26 -.255325812129631E-26
    17    17 0.110796845856717E-08 -.948736965071157E-25
    18    18 0.110796845856717E-08
    19    19 0.110796845856717E-08 -.409999501477634E-25 -.112813694359382E-25
    20    20 0.110796845856717E-08 0.940674044688116E-26
    21    21 0.110796845856717E-08
    22    22 0.110796845856717E-08 -.417928039854291E-25 -.120540659726463E-25
    23    23 0.110796845856717E-08 -.684273176507412E-25
    24    24 0.110796845856717E-08
    25    25 0.110796845856717E-08 -.158033239507603E-25 0.230061994929436E-25
    26    26 0.110796845856717E-08 -.287577493661795E-25
    27    27 0.110796845856717E-08
    28    28 0.110796845856717E-08 -.211382896042058E-25 -.112544930346614E-25
    29    29 0.110796845856717E-08 -.518177016616768E-25
    30    30 0.110796845856717E-08
-SOLUTION/MATRIX_APRIORI U COVA
*-------------------------------------------------------------------------------
%ENDSNX
```

H. 1994 Leveling Report

CORBIN GPS ANTENNA CALIBRATION SITE LEVELING

CORBIN, VIRGINIA

L25516/PART 1

MARKSETTING AUGUST 3, 1994

LEVELING AUGUST 17-18, 1994

NATIONAL GEODETIC SURVEY

Leo B. Gittings, Chief, I&E Section

Project Report by Orland W. Murray, I&E Section

LOCATION

Corbin GPS Antenna Calibration Site

The Global Positioning System (GPS) Antenna Calibration site is located about 1.2 KM (0.75 MI) east of the small rural community of Corbin, Va., Caroline County, on the grounds of the Fredericksburg Geomagnetic Center. The site is about 18 M (60 FT) east-northeast of Building 11.

SCOPE

Purpose

The purpose of this survey was to accurately determine the difference of elevation between two GPS antenna piers established for testing and calibrating various GPS antennas and ground plane configurations.

Specifications

First-Order Class II leveling specifications were adhered to for all leveling of the project.

Monumentation

Two special purpose concrete and PCV pipe piers were established. The piers were constructed as per instruction from Gerry Mader, OES Geosciences Lab. The piers consist of a concrete filled 6-inch PCV pipe projecting about 5 feet above ground level and set 2.5 feet into a concrete foundation which is 15 inches in diameter at the top and 18 inches at the bottom and 3 feet deep.

A black anodized triangular aluminum plate is cemented to the top of the pier. The plate is 7 inches on a side, has 5/8x11 inch threaded hole in the center and 3 v-grooves radiating from the center at 120 degrees. To provide leveling and azimuth orientation of the GPS antennas while maintaining no change in height, two special adapters were constructed from a standard tribrach adaptor, a Kern to Wild adapter plate and a Kern No. 489 instrument support trivet. The adapters were semi-permanently attached to the tops of the permanent aluminum plates using fabricated clamps and screws.

Each pier has two elevation points. The top flat surface of the aluminum plate permanently cemented to the top of the pier and the top flat surface of the standard tribrach adaptor of the fixed height assembly. The different

elevation points were designated as: Corbin S Pier for permanent aluminum plate and Corbin S Pier Adapter for the antenna support adaptor on the south pier. For the north pier the designations were: Corbin N Pier for the permanent aluminum plate and Corbin N Pier Adaptor for the antenna support adaptor.

Five bench marks were recovered: Designations 7550001, 7550002, 7550003, 7550004, and Flagpole. Only 7550002, 7550003, and 7550004 were leveled to during the project.

Instrumentation

1. One Zeiss/Jena NI002 level instrument S/N: 456581

2. Two Kern Double Scale Invar 3 meter rods
   #1 - S/N: 345991 #2 - S/N: 351927

3. Level tripod with two temperature probes at 0.3 M and 1.3 M, and a digital readout.

4. Adjustable height metal tripod used to support the level when observing rods on piers because normal tripod was too short.

5. Leveling data was collected using an Mcv handheld computer running the NGS Verrec software.

COMMENTS

Reconnaissance

Site selection for the two GPS antenna piers was performed as per instructions from Dr. Mader and the five bench marks for First Order, Class II level tie were recovered.

Specifications

Because of the heights of the tops of the piers above the ground, it was necessary to read below 0.5 M on the rods when leveling to the piers. The line of sight of the level was nearly 1.8 M above the ground.

Routes

Local leveling within 200 feet of bench marks for tie.

Problems

The only problem encountered was sighting the rods on top of the five foot tall piers.

Recommendations

Elevation points Corbin S Pier Adaptor and Corbin N Pier Adaptor are not permanent marks in the sense of a concrete post and could be lost if the adapters are removed which could require releveling if the adapters are not returned to their respective piers in the correct orientation. As of this report, the adapters are to be left permanently on the piers. At an opportune time, levels should be rerun at least between Corbin N Pier Adaptor and Corbin S Pier Adaptor.

CHECKS, CLOSURES AND PROGRESS

Closures

All section closures met first order class ▮▮ specifications.

Loop 7550002, 755004, Corbin N Pier, Corbin S Pier closed 0.11 mm, distance 0.14 KM, accumulated -(F+B) = 0.29 mm

Loop 7550002, 755004, Corbin N Pier Adaptor, Corbin S Pier Adaptor closed -0.11 mm, distance 0.14 KM, accumulated -(F+B) = -0.13 mm.

Check-measurements

New-Old for level tie

Designation	Distance {KM}	L25516 1994 {M}	L25415/2 1992 {M}	N-O+C_1 (M)
				C_1=O.OOOOO
7550003	0.00	67.91700	67.91700	0.00000
7550002	0.06	68.20663	68.20666	-0.00003
7550004	0.06	68.12345	68.12324	0.00021

Progress

Double run progress for the project was 0.35 KM consisting of 9 single setup sections. Total setups were 18.

Reruns

No sections required rerun.

STATUS

Records

All observation data was processed using the VFPROC (Vertical Field Data Processing) system. The data will be delivered to the NGS Vertical Branch in both hardcopy and digital formats.

Contacts

Leo B. Gittings, NGS, Chief, Instrumentation and Equipment Section (I&E Section) Ph# 703-373-7605

Orland W. Murray, NGS, I&E Section Ph# 703-373-7605

Charles C. Glover, NGS, I&E Section Ph# 703-373-7605

Leveling Personnel

Charles C. Glover, Orland W. 1urray, Kendall Fancher, Davy Crockett

ATTACHMENTS

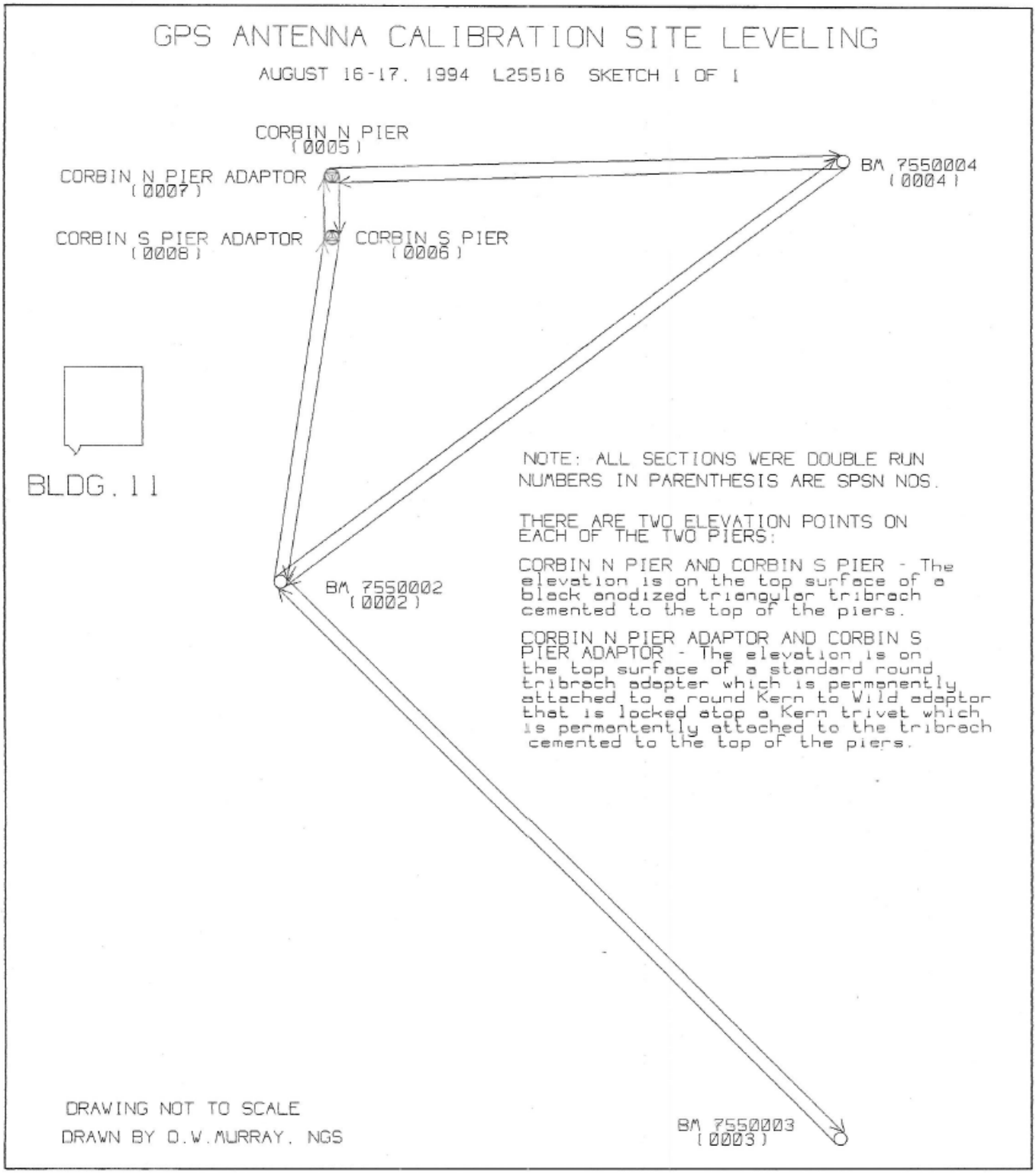
Floppy Disks

Two (1 and a backup) 3-1/2 inch High Density 1.4 Meg floppy disks containing the following files in ASCII format output by VFPROC Readfile and Newrec programs:

ANT0816.HGF	-- Observation file from VERREC
L25516.HGZ	-- Bluebook file of processed observations
L25516.HA	-- Descriptions file from DDPROC
L25516.ABS	-- Computed abstract from ABSTRA
L25516.RPT	-- Observations & computations from NEWREC

Hardcopy

40-41 Records
Field Abstract
NEWREC report
Descriptions
Loop Closure Computations
Sketch
Project Report


GPS ANTENNA CALIBRATION SITE LEVELING
AUGUST 16-17, 1994 L25516 SKETCH 1 OF 1
CORBIN N PIER
(0005)
CORBIN N PIER ADAPTOR
(0007)
BM 7550004
(0004)
CORBIN S PIER ADAPTOR
(0008)
CORBIN S PIER
(0006)
BLDG. 11
BM 7550002
(0002)
NOTE: ALL SECTIONS WERE DOUBLE RUN
NUMBERS IN PARENTHESIS ARE SPSN NOS.
THERE ARE TWO ELEVATION POINTS ON EACH OF THE TWO PIERS:
CORBIN N PIER AND CORBIN S PIER - The elevation is on the top surface of a black anodized triangular tribrach cemented to the top of the piers.
CORBIN N PIER ADAPTOR AND CORBIN S PIER ADAPTOR - The elevation is on the top surface of a standard round tribrach adapter which is permanently attached to a round Kern to Wild adaptor that is locked atop a Kern trivet which is permantently attached to the tribrach cemented to the top of the piers.
DRAWING NOT TO SCALE
DRAWN BY D.W.MURRAY, NGS
BM 7550003
(0003)

I. 1994 Leveling Field Abstract

ABSTRA Version 5.21 -- October 1991 Tue Sep 06 12:55:26 1994

-*- FIELD ABSTRACT -*-

940815-940817 HGZ L25516 1 4.0 MM ORDER 1 CLASS 2 PAGE 1

GPS ANTENNA CALIBRATION SITE AT I AND E SECTION CORBIN VA
ESTABLISH ELEVATIONS ON THE TOPS OF TWO 5 FT PIERS TO BE USED IN
CALIBRATING GPS ANTENNAS. EACH PIER HAS TWO ELEVATION POINTS.
CORBIN N PIER AND CORBIN S PIER: ELEVATIONS WERE ESTABLISHED ON THE
TOP SURFACE OF A TRIANGULAR 1/2 IN THICK TRIBRACH CEMENTED TO THE
TOPS OF THE PIERS. CORBIN N PIER ADAPTOR AND CORBIN S PIER ADAPTOR:
ELEVATIONS WERE ESTABLISHED TO THE TOP SURFACE OF A STANDARD ROUND
TRIBRACH ADAPTER PERMANENTLY ATTACHED TO A KERN FIXED HEIGHT TRIBRACH
WHICH ALLOWS LEVELING OF THE GPS ANTENNAS. THE ENTIRE ASSEMBLY IS
SEMI-PERMANENTLY ATTACHED TO THE TRIANGULAR TRIBRACHS CEMENTED TO THE
TOP OF THE PIERS.

FROM TO	START	F/B	DIST TOTAL (KM)	ELEV DIFF (MT)	-(F+B) TOTAL (MM)	MEAN DIFF FLD ELEV (MT)	I C
0003 7550003						67.91700	
0003 7550003	8171321	B	0.06	-0.28954	-0.17	0.28963	1
0002 7550002	8171325	F	0.06	0.28971			1
			0.06		-0.17	68.20663	
0002 7550002	8151416	F	0.06	-0.08323	0.01	-0.08318	1
0004 7550004	8151449	B	0.06	0.08313			1
	8151457	F	0.06	-0.08313			1
	8151527	B	0.06	0.08321			1
	SL 1		0.12		-0.16	68.12345	
0004 7550004	8151424	F	0.04	1.62100	0.16	1.62108	1
0005 CORBIN N PIER	8151445	B	0.04	-1.62116			1
	SL 1		0.16		0.00	69.74453	
0005 CORBIN N PIER	8151430	F	0.01	0.00264	0.08	0.00268	1
0006 CORBIN S PIER	8151440	B	0.01	-0.00272			1
	SL 1		0.17		0.08	69.74721	
0006 CORBIN S PIER	8151433	F	0.03	-1.54049	0.04	-1.54047	1
0002 7550002	8151436	B	0.03	1.54045			1
	SL 1		0.20		0.12	68.20674	
0002 7550002	8151516	B	0.02	-1.66520	0.01	1.66519	1
0008 CORBIN S PIER AD	8151518	F	0.03	1.66519			1
	SL 1		0.09		-0.16	69.87182	
0008 CORBIN S PIER AD	8151513	B	0.01	0.00374	-0.05	-0.00371	1
0007 CORBIN N PIER AD	8151521	F	0.02	-0.00369			1
	SL 1		0.10		-0.22	69.86811	
0007 CORBIN N PIER AD	8151509	B	0.05	1.74482	-0.10	-1.74477	1
0004 7550004	8151523	F	0.05	-1.74472			1
	SL 1		0.15		-0.32	68.12334	

J. 1995 3-D Project Report

PROJECT REPORT

3D TIE TO ASTRO EAST PIER (ASTE)
OF CORBIN N PIER ADAPTOR (CNPA) AND
CORBIN S PIER ADAPTOR (CSPA)

CORBIN, VIRGINIA

8 NOVEMBER 1995 - 9 NOVEMBER 1995

U. S. DEPARTMENT OF COMMERCE

NATIONAL GEODETIC SURVEY

CAPT. LEWIS A. LAPINE - CHIEF

CHARLES C. GLOVER - PROJECT DIRECTOR

Project conducted for:

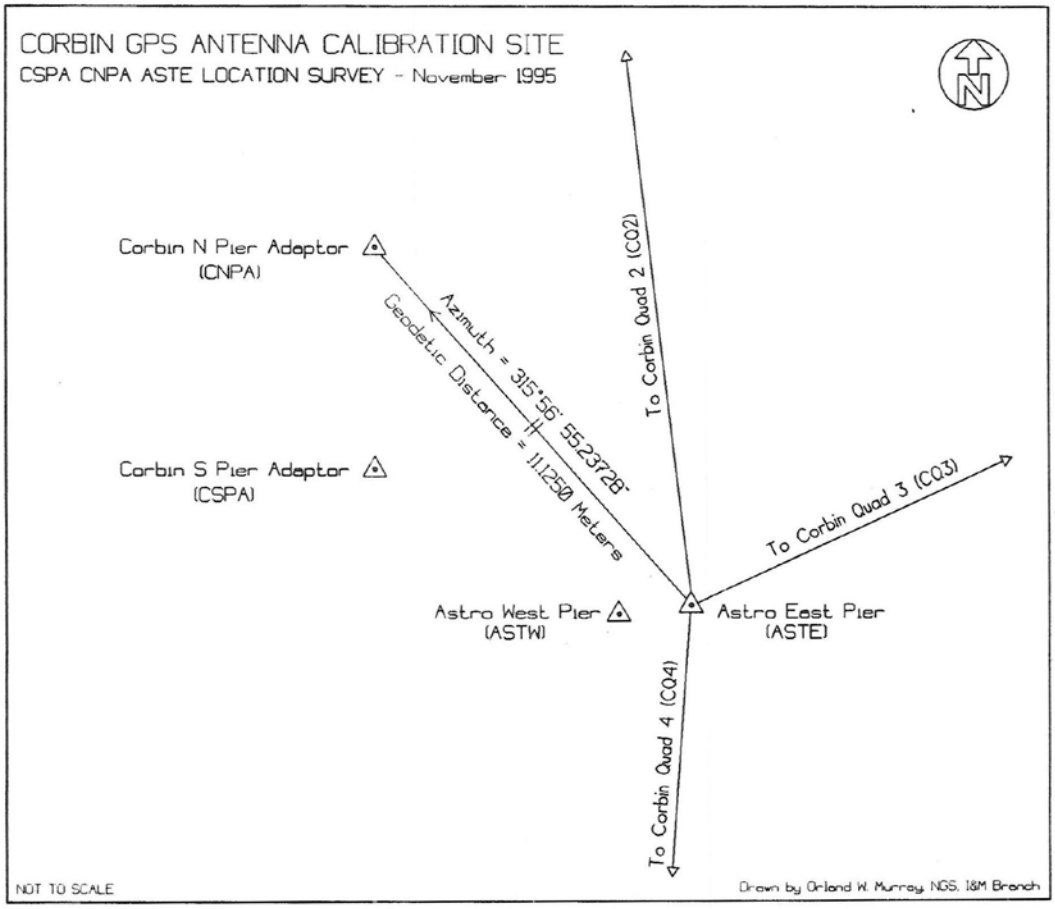
Dr. Gerald L. Mader - Supervisory Geodesist
Advanced Technology Branch
Office of Ocean and Earth Sciences
N/OES13, NOS/NOAA/Department of Commerce

Report written and prepared by:

Charles C. Glover
NGSD, Instrumentation & Methodology Branch

Orland W. Murray
NGSD, Instrumentation & Methodology Branch

November 1995



SKETCH OF GPS ANTENNA CALIBRATION SITE

This 3-D survey was conducted to establish a 3 dimensional tie from ASTRO EAST PIER (ASTE) to two GPS antenna test piers. The test piers are designated CORBIN S PIER ADAPTOR (CSPA) and CORBIN N PIER ADAPTOR (CNPA).

ASTRO EAST PIER is a GPS derived station of B Order accuracy. There is no other station in the area of sufficient accuracy and distance from ASTRO EAST PIER to serve as a azimuth station to conduct this survey.

However, the Corbin Quadrangle, while being published as third order and consequently in a different system from ASTRO EAST PIER, is internally accurate at the sub-millimeter level in relative positions. The orientation of the quadrangle was determined through first order observations on Polaris.

For the purpose of this survey, CORBIN QUAD 2 (CQ2), CORBIN QUAD 3 (CQ3) AND CORBIN QUAD 4 (CQ4) were used to establish a position on ASTRO EAST PIER (ASTE) in the CORBIN QUADRANGLE system.

The difference in the published NAD 83 (1993) position of ASTRO EAST PIER and the position established in the CORBIN QUADRANGLE system was computed. These difference values were used to correct each of the quadrangle stations into the ASTRO EAST PIER system.

The positioning of ASTRO EAST PIER relative to the quadrange was accomplished by distance and direction observations to ASTRO EAST PIER from each of the three above quadrangle stations, using the other two quadrangle stations as backsights (azimuths).

The internal consistency of these observations were checked by computing a traverse which included ASTRO EAST PIER and the three quadrangle stations. The traverse started and closed on the same station for position closure.

TRAVERSE COMPUTATION FOR POSITION CLOSURE

SPN	STATION NAME	DISTANCE METERS		AZIMUTHS	LATITUDE / LONGITUDE
	CORBIN QUAD 2		/INV/ BCK	355-35-18.448	
4	CORBIN QUAD 4		ANGLE	038-37-24.898	038-12-05.06195
		127.2316	FWD	034-12-43.347	077-22-24.19466
			BCK	214-12-45.165	
3	CORBIN QUAD 3		ANGLE	101-19-46.498	038-12-08.47433
		123.4342	FWD	315-32-31.664	077-22-21.25447
			BCK	135-32-29.467	
2	CORBIN QUAD 2		ANGLE	038-11-36.200	038-12-11.33171
		121.8282	FWD	173-44-05.667	077-22-24.80769
			BCK	353-44-06.005	
5	ASTRO EAST PIER		ANGLE	184-58-40.800	038-12-07.40413
		72.2355	FWD	178-42-46.805	077-22-24.26127
			BCK	358-42-46.846	
4	CORBIN QUAD 4		ANGLE	035-29-56.198	038-12-05.06196
	CORBIN QUAD 3		FWD	034-12-43.045	077-22-24.19458

DLAT/DLON =	.000	.002	/INV/	034-12-47.142	-4.098
CLOSURE =	.002 /	.44 KM		ONE PART IN	236000

The azimuth was closed on the first forward azimuth from the starting station:

TRAVERSE COMPUTATION FOR AZIMUTH CLOSURE

SPN	STATION NAME	DISTANCE METERS		AZIMUTHS	LATITUDE LONGITUDE
	CORBIN QUAD 2		/AZI/ BCK	355-35-18.448	
4	CORBIN QUAD 4		ANGLE	038-37-25.718	038-12-05.06195
		127.2316	FWD	034-12-44.166	077-22-24.19466
			BCK	214-12-45.985	
3	CORBIN QUAD 3		ANGLE	101-19-47.318	038-12-08.47432
		123.4342	FWD	315-32-33.303	077-22-21.25446
			BCK	135-32-31.106	
2	CORBIN QUAD 2		ANGLE	038-11-37.019	038-12-11.33173
		121.8282	FWD	173-44-08.126	077-22-24.80766
			BCK	353-44-08.463	
5	ASTRO EAST PIER		ANGLE	184-58-41.619	038-12-07.40413
		72.2355	FWD	178-42-50.083	077-22-24.26132
			BCK	358-42-50.124	
4	CORBIN QUAD 4		ANGLE	035-29-57.017	038-12-05.06196
	CORBIN QUAD 3		FWD	034-12-47.142	077-22-24.19463

DLAT/DLON = .000 .001 /AZI/ 034-12-47.142
CLOSURE = .001 / .44 KM ONE PART IN 600000

Due to the fact that the azimuth closure was considerably better than the position closure in addition to the shortness of the lines and the strength of the geometrical relation of the control stations, it was decided to position CSPA and CNPA by intersection from ASTRO EAST PIER and the other quadrangle stations. The results of these computations follow:

SPECIAL COMPUTATIONS --- INTERSECTION

		ORIGINAL	ADJUSTED	STD ERROR
6	CSPA	LAT 038-12-07.50213 N	038-12-07.50215	.00001
		LON 077-22-24.58213 W	077-22-24.58219	.00001
	(ERROR ELLIPSE)	AZ= 117-09-39.5	MAX,MIN= .3	.2 (MM)

SPN	STATION NAME	DISTANCE (METERS)	WGT	AZIMUTH DDD-MM-SS.SS	RESIDUAL SS.SS
4	CORBIN QUAD 4	75.828	.01	352-51-26.31	-1.016
3	CORBIN QUAD 3	86.337	.02	249-41-08.60	.573
2	CORBIN QUAD 2	118.204	.03	177-20-25.70	-1.076
5	ASTRO EAST PIER	8.373	.00	291-09-55.67	-1.840
5	ASTRO EAST PIER	8.373	.00	291-09-57.54	-3.707
5	ASTRO EAST PIER	8.373	.00	291-09-52.84	.997

ITERATION 2

DEGREES FREEDOM = 4 VARIANCE UNIT WGT = .0136 UNIT WGT = .1164

SPECIAL COMPUTATIONS --- INTERSECTION

		ORIGINAL	ADJUSTED	STD ERROR
7 CNPA	LAT	038-12-07.66348 N	038-12-07.66342	.00001
	LON	077-22-24.57927 W	077-22-24.57919	.00001

(ERROR ELLIPSE) AZ= 144-53-29.3 MAX,MIN= .3 .2 (MM)

SPN	STATION NAME	DISTANCE (METERS)	WGT	AZIMUTH DDD-MM-SS.SS	RESIDUAL SS.SS
4	CORBIN QUAD 4	80.756	.01	353-20-51.02	-1.161
3	CORBIN QUAD 3	84.670	.02	252-49-33.00	.360
2	CORBIN QUAD 2	113.241	.03	177-11-12.60	-1.267
5	ASTRO EAST PIER	11.125	.00	315-56-57.67	-1.226
5	ASTRO EAST PIER	11.125	.00	315-56-59.54	-3.093
5	ASTRO EAST PIER	11.125	.00	315-56-54.84	1.611

ITERATION 2

DEGREES FREEDOM = 4 VARIANCE UNIT WGT = .0169 UNIT WGT = .1301

INVERSE COMPUTATIONS

STATION ... "FROM"	AZIMUTHS/DISTANCE	STATION ... "TO"
ASTRO EAST PIER	-INVERSE-	CNPA
SPN LAT 038-12-07.40410 N 5 LON 077-22-24.26127 W	FWD 315-56-55.23728 BCK 135-56-55.04067 DST 11.1250	SPN LAT 038-12-07.66342 N 7 LON 077-22-24.57919 W
ASTRO EAST PIER	-INVERSE-	CSPA
SPN LAT 038-12-07.40410 N 5 LON 077-22-24.26127 W	FWD 291-09-56.23538 BCK 111-09-56.03692 DST 8.3731	SPN LAT 038-12-07.50215 N 6 LON 077-22-24.58219 W
ASTRO EAST PIER	-INVERSE-	ASTRO WEST PIER
SPN LAT 038-12-07.40410 N 5 LON 077-22-24.26127 W	FWD 264-38-08.97052 BCK 084-38-08.90907 DST 2.4274	SPN LAT 038-12-07.39674 N 8 LON 077-22-24.36060 W
CSPA	-INVERSE-	CNPA
SPN LAT 038-12-07.50215 N 6 LON 077-22-24.58219 W	FWD 000-50-27.82694 BCK 180-50-27.82879 DST 4.9730	SPN LAT 038-12-07.66342 N 7 LON 077-22-24.57919 W
ASTRO WEST PIER	-INVERSE-	CSPA
SPN LAT 038-12-07.39674 N 8 LON 077-22-24.36060 W	FWD 301-04-58.78358 BCK 121-04-58.64655 DST 6.2953	SPN LAT 038-12-07.50215 N 6 LON 077-22-24.58219 W
ASTRO WEST PIER	-INVERSE-	CNPA
SPN LAT 038-12-07.39674 N 8 LON 077-22-24.36060 W	FWD 327-06-17.94018 BCK 147-06-17.80499 DST 9.7928	SPN LAT 038-12-07.66342 N 7 LON 077-22-24.57919 W

CSPA CNPA ASTE LOCATION SURVEY
LIST OF ELEVATIONS & GEOID HGT

SPN	STATION NAME	HGT CODE K	ELEVATION (M)	GEOID HGT (M)	ELEVATION SOURCE
5	ASTRO EAST PIER	5	69.7822	-32.990	NGS
6	CSPA	9	69.8718		NGS
7	CNPA	9	69.8681		NGS

GPN XYZ COMPUTATIONS

SPN	STATION NAME	GEOGRAPHIC POSITION (DDD MM SS.SSS)	HEIGHTS (METERS)	COORDINATES (METERS)
5	ASTRO EAST PIER	LAT 038-12-07.40410 N	0.000 I	1097051.0265 X
		LON 077-22-24.26127 W	69.782 E	-4897245.7925 Y
		HGT 36.7921 M	-32.990 G	3923115.8175 Z
6	CSPA	LAT 038-12-07.50215 N	0.000 I	1097043.0137 X
		LON 077-22-24.58219 W	69.872 E	-4897245.7436 Y
		HGT 36.8818 M	-32.990 G	3923118.2487 Z
7	CNPA	LAT 038-12-07.66342 N	0.000 I	1097042.4121 X
		LON 077-22-24.57919 W	69.868 E	-4897242.7240 Y
		HGT 36.8781 M	-32.990 G	3923122.1540 Z

NOTE: Instrument mounting fixture above datum point on Astro East Pier = 0.159 meters.