



**GEOD** CORPORATION

PHOTOGRAMMETRIC SCIENCES - SURVEY TECHNOLOGIES

March 25, 2004

Keystone Aerial Surveys, Inc.  
Northeast Philadelphia Airport  
Philadelphia, Pennsylvania 19114

Attn: Mike Rambo

Re: Measurement Report

GEOD Corporation was retained by Keystone Aerial Surveys, Inc. to determine the horizontal and vertical offset of the GPS antenna mounted on the exterior of aircraft No. N69622 from the film plane of the Leica RC30 photogrammetric camera (Serial Number 5297) mounted within. The purpose of this report is to document the procedures used and present the final results of the combined measurements.

Upon arrival at Keystone's hangar, GEOD personnel determined the best orientation of the aircraft to facilitate the measurements. Keystone personnel then jacked the aircraft into the predetermined normal flight attitude. Measurement points were marked and numbered on the exterior of the aircraft. A point in the center of the nose (point number 100) and a point on top of a fin at the base of the rudder (point number 103) were selected to define the Y measurement axis. A screw in a similar position on each wing tank (point number 102 starboard side and point number 101 port side) was selected to define the X measurement axis. The screws securing the GPS antenna to the exterior of the plane (point numbers 104 through 107) were numbered beginning with the forward side screw and proceeding clockwise. On the camera inside the aircraft, the four holes through which the center fiducial marks are projected (points 108 through 111) were numbered beginning with the forward hole and proceeding clockwise.

The first measurements made were between the camera fiducial marks. Using an Alvin engineers scale graduated to a half millimeter, the distance between adjacent and opposite fiducial marks was measured. The same measurements were made between the screws on the GPS antenna.

Next, three observation points (point numbers 1 through 3) were set up around the aircraft to collect the measurements that would determine the relative horizontal position of the aircraft, the camera, and the GPS antenna. All the points on the camera could be observed from both points 2 and 3. All the exterior points could be observed from points 1 and 3, while observation point 2 could see the starboard wing point, the tail point and the GPS points. These measurements were made using a Topcon GTS-300 total station. This instrument's angular accuracy is specified at "1 second standard deviation based on DIN18723" and its distance accuracy is specified at "+/- 2 mm + 2 ppm". All distance measurements were made using the instruments internal EDM to a mini-prism assembly placed on the measurement point.

Finally, measurements were made to determine the vertical offset of the GPS antenna from the camera film plane. First, a spot on the hangar floor near the location of the GPS antenna was

marked. Using a carpenter's level and a Lufkin steel rule graduated in millimeters, the distance from the top of the dome of the antenna to the mark on the hangar floor was measured. A Zeiss NI-2 automatic level was then employed to level from the mark on the hangar floor to each of the camera fiducial marks. An engineer's scale was then used to measure from the top dome of the GPS antenna to each of the screws.

All of these physical measurements were then combined into a least squares adjustment. The point on the tail (point number 103) was assigned the horizontal coordinate of (0,0). The starboard fiducial mark (point number 109) was assigned the elevation of 0. The direction from the tail point to the nose point (point number 100) was set as the positive Y axis. Additionally, the angles between adjacent fiducial marks and GPS antenna screws were constrained to be close to 90 degrees. The adjustment resulted in standard deviations for the camera and antenna points of approximately 1.5 mm. The full results can be viewed in the included copy of the adjustment output listing.

The final horizontal position of the center of the film plane (point number 200) and the center of the GPS antenna (point number 201) were computed by mathematically intersecting the opposite measurement points on each. The final vertical position of the film plane was computed by averaging the vertical position of each fiducial mark. The final vertical position of the top of the dome of the antenna was taken from the level adjustment.

Based on these observations, the center of the film plane is 0.0058 M to port, 0.0041 M aft, and 0.8673 M below the top center of the dome of the GPS antenna.

Please note that the final position of the camera film plane (point 200) is the mathematical intersection of the holes through which the center fiducial marks are projected. The user of these observations should consult with the manufacturer's published camera geometry to relate these observation locations to camera geometry such as the "entrance node" and/or the "rear node" needed for airborne GPS computations. Also, the final position of the GPS antenna (point 201) is the center of the antenna at the top of the dome. The L1 & L2 phase center relationship to this point is to be determined by separate observations.

Sincerely,

GEOD Corporation

Paul J. Emilius Jr., PLS  
Vice President Surveying

Summary of Files Used and Option Settings  
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Project Folder and Data Files

Project Name AIRCRAFT #69622  
Project Folder G:\1608\AIRCRAFT #N69622-01-23-04\STARNET  
Data File List Aircraft #69622.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) : 0.002000 Meters  
Distances (PPM) : 2.000000  
Angles : 10.000000 Seconds  
Directions : 10.000000 Seconds  
Azimuths & Bearings : 20.000000 Seconds  
Zeniths : 10.000000 Seconds  
Elevation Differences (Constant) : 0.015240 Meters  
Elevation Differences (PPM) : 0.000000  
Differential Levels : 0.002403 Meters / Km  
Centering Error Instrument : 0.000000 Meters  
Centering Error Target : 0.000000 Meters  
Centering Error Vertical : 0.000000 Meters

Project Library Instrument Sideshots

Note: n/a  
Distances (Constant) : 0.002000 Meters  
Distances (PPM) : 2.000000  
Angles : 5.000000 Seconds  
Directions : 5.000000 Seconds  
Azimuths & Bearings : 5.000000 Seconds  
Zeniths : 5.000000 Seconds  
Elevation Differences (Constant) : 0.002000 Meters  
Elevation Differences (PPM) : 0.000000  
Differential Levels : 0.002403 Meters / Km  
Centering Error Instrument : 0.000000 Meters  
Centering Error Target : 0.002000 Meters  
Centering Error Vertical : 0.002000 Meters

Project Library Instrument Traverse

Note: n/a  
Distances (Constant) : 0.002000 Meters

Distances (PPM)	:	2.000000
Angles	:	5.000000 Seconds
Directions	:	5.000000 Seconds
Azimuths & Bearings	:	5.000000 Seconds
Zeniths	:	5.000000 Seconds
Elevation Differences (Constant)	:	0.002000 Meters
Elevation Differences (PPM)	:	0.000000
Differential Levels	:	0.002403 Meters / Km
Centering Error Instrument	:	0.000000 Meters
Centering Error Target	:	0.000000 Meters
Centering Error Vertical	:	0.000000 Meters

Summary of Unadjusted Input Observations

Number of Entered Stations (Meters) = 15

Partially Fixed	N	E	Elev	Description
	StdErr	StdErr	StdErr	
103	0.0000	0.0000	0.4833	TAIL
	FIXED	FIXED	FREE	
109	4.2596	-0.1541	0.0000	CAMERA POINT
	FREE	FREE	FIXED	
104	4.2937	-0.2600	0.8613	GPS
	FREE	FREE	0.0015	
105	4.2599	-0.2267	0.8623	GPS
	FREE	FREE	0.0015	
106	4.2256	-0.2594	0.8623	GPS
	FREE	FREE	0.0015	
107	4.2591	-0.2939	0.8613	GPS
	FREE	FREE	0.0015	
108	4.3674	-0.2702	0.0003	CAMERA
	FREE	FREE	0.0015	
110	4.1437	-0.2620	0.0003	CAMERA
	FREE	FREE	0.0015	
111	4.2514	-0.3779	-0.0009	CAMERA
	FREE	FREE	0.0015	

Free Stations	N	E	Elev	Description
2	1.0103	4.3140	-1.5191	TR_XCT
3	11.5686	4.0817	-1.5294	TR_XCT
100	8.1688	0.0000	-0.2947	NOSE
1	12.1950	-2.8109	-1.5410	TR_XCT
101	6.6330	-5.4238	0.2390	WING
102	6.6118	5.4498	0.1992	WING

Number of Angle Observations (DMS) = 68

At	From	To	Angle	StdErr
108	109	111	90-00-00.00	FIXED
111	108	110	90-00-00.00	FIXED
110	111	109	90-00-00.00	FIXED
109	110	108	90-00-00.00	FIXED
104	105	107	90-00-00.00	0.00
107	104	106	90-00-00.00	0.00
106	107	105	90-00-00.00	0.00
105	106	104	90-00-00.00	0.00
1	2	3	307-41-36.00	5.00
1	3	2	52-18-29.70	5.00
3	1	2	263-32-55.20	5.00
3	2	1	96-27-03.00	5.00
2	1	3	31-14-08.50	5.00
2	3	1	328-45-49.50	5.00
1	2	100	357-34-48.50	89.73
1	2	101	57-39-47.50	74.16
1	2	102	336-33-08.00	52.01
1	2	103	19-31-13.50	45.60
1	2	104	14-36-45.00	58.83
1	2	105	14-27-26.50	58.62
1	2	106	14-45-00.00	58.51
1	2	107	14-54-22.00	58.72
1	3	100	49-53-21.00	103.13
1	3	101	109-58-24.00	89.91
1	3	102	28-51-36.00	72.73
1	3	103	71-49-42.50	68.30
1	3	104	66-55-05.00	77.76
1	3	105	66-46-00.50	77.60

1	3	106	67-03-19.50	77.51
1	3	107	67-12-48.50	77.67
3	1	100	315-00-35.00	98.02
3	1	101	327-21-47.50	71.14
3	1	102	249-22-59.00	100.07
3	1	103	284-14-47.00	68.62
3	1	105	295-20-17.00	77.09
3	1	108	295-57-12.50	77.34
3	1	109	294-53-57.00	77.22
3	1	110	295-08-16.00	76.67
3	1	111	296-10-01.50	76.78
3	2	100	51-27-33.00	87.07
3	2	101	63-48-48.50	55.09
3	2	102	345-50-01.00	89.37
3	2	103	20-41-50.00	51.78
3	2	105	31-47-00.50	62.57
3	2	108	32-24-19.50	62.89
3	2	109	31-21-03.00	62.73
3	2	110	31-35-20.50	62.05
3	2	111	32-37-20.50	62.20
2	1	102	43-57-35.00	78.75
2	1	103	289-19-02.50	98.29
2	1	104	338-10-11.00	79.75
2	1	105	338-05-47.00	80.32
2	1	106	337-36-22.50	80.24
2	1	107	337-41-09.00	79.66
2	1	108	338-42-45.00	79.15
2	1	109	338-31-36.50	81.05
2	1	110	336-53-59.50	80.78
2	1	111	337-08-10.00	78.91
2	3	102	12-44-16.00	82.22
2	3	103	258-04-54.50	101.09
2	3	104	306-56-19.00	83.18
2	3	105	306-51-44.50	83.72
2	3	106	306-22-17.50	83.64
2	3	107	306-26-56.50	83.09
2	3	108	307-28-46.50	82.60
2	3	109	307-17-35.00	84.42
2	3	110	305-40-12.50	84.16
2	3	111	305-54-21.00	82.37

Number of Distance Observations (Meters) = 84

From	To	Distance	StdErr	HI	HT	Type
109	111	0.2240	0.0005	0.000	0.000	S
108	110	0.2240	0.0005	0.000	0.000	S
109	110	0.1585	0.0005	0.000	0.000	S
110	111	0.1585	0.0005	0.000	0.000	S
111	108	0.1585	0.0005	0.000	0.000	S
108	109	0.1585	0.0005	0.000	0.000	S
105	107	0.0681	0.0005	0.000	0.000	S
104	106	0.0681	0.0005	0.000	0.000	S
104	105	0.0481	0.0005	0.000	0.000	S
105	106	0.0481	0.0005	0.000	0.000	S
106	107	0.0481	0.0005	0.000	0.000	S
107	104	0.0481	0.0005	0.000	0.000	S
1	2	13.2608	0.0020	0.000	0.000	S
1	3	6.9207	0.0020	0.000	0.000	S
1	2	13.2608	0.0020	0.000	0.000	S
1	3	6.9207	0.0020	0.000	0.000	S
1	2	13.2615	0.0020	0.000	0.000	S
1	3	6.9204	0.0020	0.000	0.000	S
3	1	6.9204	0.0020	0.000	0.000	S
3	2	10.5615	0.0020	0.000	0.000	S
3	1	6.9212	0.0020	0.000	0.000	S
3	2	10.5612	0.0020	0.000	0.000	S

3	1	6.9210	0.0020	0.000	0.000	S
3	2	10.5615	0.0020	0.000	0.000	S
2	1	13.2615	0.0020	0.000	0.000	S
2	3	10.5610	0.0020	0.000	0.000	S
2	1	13.2618	0.0020	0.000	0.000	S
2	3	10.5615	0.0020	0.000	0.000	S
2	1	13.2610	0.0020	0.000	0.000	S
2	3	10.5615	0.0020	0.000	0.000	S
1	100	5.0651	0.0029	0.000	0.000	S
1	101	6.3966	0.0029	0.000	0.000	S
1	102	10.1207	0.0029	0.000	0.000	S
1	103	12.6770	0.0029	0.000	0.000	S
1	104	8.6383	0.0029	0.000	0.000	S
1	105	8.6787	0.0029	0.000	0.000	S
1	106	8.7000	0.0029	0.000	0.000	S
1	107	8.6595	0.0029	0.000	0.000	S
1	100	5.0650	0.0029	0.000	0.000	S
1	101	6.3965	0.0029	0.000	0.000	S
1	102	10.1204	0.0029	0.000	0.000	S
1	103	12.6770	0.0029	0.000	0.000	S
1	104	8.6377	0.0029	0.000	0.000	S
1	105	8.6786	0.0029	0.000	0.000	S
1	106	8.7009	0.0029	0.000	0.000	S
1	107	8.6605	0.0029	0.000	0.000	S
3	100	5.4531	0.0029	0.000	0.000	S
3	101	10.8561	0.0029	0.000	0.000	S
3	102	5.4250	0.0029	0.000	0.000	S
3	103	12.4323	0.0029	0.000	0.000	S
3	105	8.8103	0.0029	0.000	0.000	S
3	108	8.5520	0.0029	0.000	0.000	S
3	109	8.5856	0.0029	0.000	0.000	S
3	110	8.7377	0.0029	0.000	0.000	S
3	111	8.7052	0.0029	0.000	0.000	S
3	100	5.4538	0.0029	0.000	0.000	S
3	101	10.8562	0.0029	0.000	0.000	S
3	102	5.4245	0.0029	0.000	0.000	S
3	103	12.4323	0.0029	0.000	0.000	S
3	105	8.8137	0.0029	0.000	0.000	S
3	108	8.5524	0.0029	0.000	0.000	S
3	109	8.5857	0.0029	0.000	0.000	S
3	110	8.7376	0.0029	0.000	0.000	S
3	111	8.7051	0.0029	0.000	0.000	S
2	102	5.9680	0.0029	0.000	0.000	S
2	103	4.8612	0.0030	0.000	0.000	S
2	104	6.1062	0.0029	0.000	0.000	S
2	105	6.0634	0.0029	0.000	0.000	S
2	106	6.0689	0.0029	0.000	0.000	S
2	107	6.1127	0.0029	0.000	0.000	S
2	108	5.8823	0.0029	0.000	0.000	S
2	109	5.7309	0.0029	0.000	0.000	S
2	110	5.7498	0.0029	0.000	0.000	S
2	111	5.9017	0.0029	0.000	0.000	S
2	102	5.9680	0.0029	0.000	0.000	S
2	103	4.8616	0.0030	0.000	0.000	S
2	104	6.1052	0.0029	0.000	0.000	S
2	105	6.0619	0.0029	0.000	0.000	S
2	106	6.0694	0.0029	0.000	0.000	S
2	107	6.1132	0.0029	0.000	0.000	S
2	108	5.8809	0.0029	0.000	0.000	S
2	109	5.7298	0.0029	0.000	0.000	S
2	110	5.7503	0.0029	0.000	0.000	S
2	111	5.9003	0.0029	0.000	0.000	S

Number of Zenith Observations (DMS) = 72

From	To	Zenith	StdErr	HI	HT
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1	2	89-54-18.90	5.00	0.000	0.000
1	3	89-54-09.60	5.00	0.000	0.000
1	2	89-54-20.60	5.00	0.000	0.000
1	3	89-54-12.80	5.00	0.000	0.000
1	2	89-54-18.70	5.00	0.000	0.000
1	3	89-54-15.80	5.00	0.000	0.000
3	1	90-05-51.70	5.00	0.000	0.000
3	2	89-56-39.40	5.00	0.000	0.000
3	1	90-05-48.60	5.00	0.000	0.000
3	2	89-56-39.70	5.00	0.000	0.000
3	1	90-05-51.10	5.00	0.000	0.000
3	2	89-56-41.70	5.00	0.000	0.000
2	1	90-05-39.10	5.00	0.000	0.000
2	3	90-03-26.30	5.00	0.000	0.000
2	1	90-05-42.10	5.00	0.000	0.000
2	3	90-03-25.10	5.00	0.000	0.000
2	1	90-05-40.30	5.00	0.000	0.000
2	3	90-03-27.30	5.00	0.000	0.000
1	100	75-45-43.50	113.52	0.000	0.000
1	101	73-50-40.40	89.55	0.000	0.000
1	102	80-06-16.00	57.43	0.000	0.000
1	103	80-48-57.60	46.00	0.000	0.000
1	104	73-58-08.20	66.37	0.000	0.000
1	105	74-03-04.80	66.07	0.000	0.000
1	106	74-05-22.60	65.91	0.000	0.000
1	107	74-00-36.40	66.21	0.000	0.000
1	100	75-44-53.70	113.52	0.000	0.000
1	101	73-50-53.80	89.55	0.000	0.000
1	102	80-06-53.00	57.43	0.000	0.000
1	103	80-48-51.70	46.00	0.000	0.000
1	104	73-58-25.40	66.37	0.000	0.000
1	105	74-03-16.70	66.07	0.000	0.000
1	106	74-05-34.10	65.91	0.000	0.000
1	107	74-00-48.80	66.21	0.000	0.000
3	100	76-54-34.80	105.71	0.000	0.000
3	101	80-37-29.50	53.62	0.000	0.000
3	102	71-24-30.90	104.90	0.000	0.000
3	103	80-41-00.80	46.89	0.000	0.000
3	105	74-22-09.80	65.15	0.000	0.000
3	108	79-41-28.60	67.86	0.000	0.000
3	109	79-44-30.60	67.60	0.000	0.000
3	110	79-55-24.60	66.45	0.000	0.000
3	111	79-53-11.40	66.69	0.000	0.000
3	100	76-55-17.40	105.71	0.000	0.000
3	101	80-37-18.80	53.62	0.000	0.000
3	102	71-24-20.90	104.90	0.000	0.000
3	103	80-40-54.50	46.89	0.000	0.000
3	105	74-22-33.40	65.15	0.000	0.000
3	108	79-41-41.90	67.86	0.000	0.000
3	109	79-44-27.30	67.60	0.000	0.000
3	110	79-55-30.40	66.45	0.000	0.000
3	111	79-53-17.20	66.69	0.000	0.000
2	102	73-15-33.00	95.84	0.000	0.000
2	103	65-39-56.50	114.90	0.000	0.000
2	104	67-13-15.10	91.88	0.000	0.000
2	105	67-03-01.00	92.47	0.000	0.000
2	106	67-04-22.10	92.38	0.000	0.000
2	107	67-14-41.90	91.79	0.000	0.000
2	108	75-01-56.30	97.65	0.000	0.000
2	109	74-37-23.70	100.14	0.000	0.000
2	110	74-41-18.00	99.79	0.000	0.000
2	111	75-05-50.50	97.34	0.000	0.000
2	102	73-15-32.60	95.84	0.000	0.000
2	103	65-40-06.00	114.90	0.000	0.000
2	104	67-13-11.00	91.88	0.000	0.000
2	105	67-02-53.80	92.47	0.000	0.000



From	To	Bearing	StdErr	FIXED	Number of Azimuth/Bearing Observations (DMS) = 1
2	106	67-04-24.20	92.38	0.000	0.000
2	107	67-14-43.90	91.79	0.000	0.000
2	108	75-01-38.90	97.65	0.000	0.000
2	109	74-37-30.50	100.14	0.000	0.000
2	110	74-41-24.80	99.79	0.000	0.000
2	111	75-05-31.80	97.34	0.000	0.000

Adjustment Statistical Summary

=====  
Convergence Iterations = 5  
Number of Stations = 15  
Number of Observations = 232  
Number of Unknowns = 42  
Number of Redundant Obs = 190

Observation	Count	Sum Squares of StdRes	Error Factor
Coordinates	7	72.489	3.556
Angles	68	14.126	0.504
Distances	84	16.875	0.495
Az/Bearings	1	0.000	0.000
Zeniths	72	88.071	1.222
Total	232	191.560	1.004

The Chi-Square Test at 5.00% Level Passed  
Lower/Upper Bounds (0.899/1.100)

Adjusted Coordinates (Meters)

=====

Station	N	E	Elev	Description
2	1.0102	4.3140	-1.5112	TR_XCT
3	11.5686	4.0817	-1.5215	TR_XCT
103	0.0000	0.0000	0.4912	TAIL
100	8.1688	-0.0000	-0.2869	NOSE
109	4.2596	-0.1541	0.0000	CAMERA POINT
1	12.1950	-2.8109	-1.5332	TR_XCT
101	6.6331	-5.4238	0.2468	WING
102	6.6117	5.4498	0.2071	WING
104	4.2936	-0.2605	0.8565	GPS
105	4.2599	-0.2262	0.8558	GPS
106	4.2256	-0.2599	0.8570	GPS
107	4.2593	-0.2942	0.8567	GPS
108	4.3674	-0.2701	0.0046	CAMERA
110	4.1435	-0.2619	0.0040	CAMERA
111	4.2514	-0.3780	0.0032	CAMERA

Adjusted Observations and Residuals

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

Station	Component	Adj Coordinate	Residual	StdErr	StdRes
104	Elev	0.8565	-0.0048	0.0015	3.2*
105	Elev	0.8558	-0.0065	0.0015	4.3*
106	Elev	0.8570	-0.0053	0.0015	3.5*
107	Elev	0.8567	-0.0046	0.0015	3.1*
108	Elev	0.0046	0.0043	0.0015	2.9
110	Elev	0.0040	0.0037	0.0015	2.4
111	Elev	0.0032	0.0041	0.0015	2.8

Adjusted Angle Observations (DMS)

At	From	To	Angle	Residual	StdErr	StdRes
108	109	111	90-00-00.00	-0-00-00.00	FIXED	0.0
111	108	110	90-00-00.00	0-00-00.00	FIXED	0.0
110	111	109	90-00-00.00	-0-00-00.00	FIXED	0.0
109	110	108	90-00-00.00	0-00-00.00	FIXED	0.0
104	105	107	90-00-00.00	-0-00-00.00	0.00	0.0
107	104	106	90-00-00.00	0-00-00.00	0.00	0.0
106	107	105	90-00-00.00	-0-00-00.00	0.00	0.0
105	106	104	90-00-00.00	0-00-00.00	0.00	0.0
1	2	3	307-41-25.87	-0-00-10.13	5.00	2.0
1	3	2	52-18-34.13	0-00-04.43	5.00	0.9
3	1	2	263-32-49.79	-0-00-05.41	5.00	1.1
3	2	1	96-27-10.21	0-00-07.21	5.00	1.4
2	1	3	31-14-15.66	0-00-07.16	5.00	1.4
2	3	1	328-45-44.34	-0-00-05.16	5.00	1.0
1	2	100	357-34-37.00	-0-00-11.50	89.73	0.1
1	2	101	57-39-39.87	-0-00-07.63	74.16	0.1
1	2	102	336-33-06.15	-0-00-01.85	52.01	0.0
1	2	103	19-31-04.73	-0-00-08.77	45.60	0.2
1	2	104	14-36-31.23	-0-00-13.77	58.83	0.2
1	2	105	14-27-19.79	-0-00-06.71	58.62	0.1
1	2	106	14-44-51.96	-0-00-08.04	58.51	0.1
1	2	107	14-54-07.30	-0-00-14.70	58.72	0.3
1	3	100	49-53-11.13	-0-00-09.87	103.13	0.1
1	3	101	109-58-14.00	-0-00-10.00	89.91	0.1
1	3	102	28-51-40.28	0-00-04.28	72.73	0.1
1	3	103	71-49-38.86	-0-00-03.64	68.30	0.1
1	3	104	66-55-05.36	0-00-00.36	77.76	0.0
1	3	105	66-45-53.92	-0-00-06.58	77.60	0.1
1	3	106	67-03-26.09	0-00-06.59	77.51	0.1
1	3	107	67-12-41.43	-0-00-07.07	77.67	0.1
3	1	100	315-00-55.41	0-00-20.41	98.02	0.2
3	1	101	327-22-03.78	0-00-16.28	71.14	0.2
3	1	102	249-22-40.07	-0-00-18.93	100.07	0.2
3	1	103	284-14-29.51	-0-00-17.49	68.62	0.3
3	1	105	295-19-23.56	-0-00-53.44	77.09	0.7
3	1	108	295-57-10.44	-0-00-02.06	77.34	0.0
3	1	109	294-54-03.34	0-00-06.34	77.22	0.1
3	1	110	295-08-05.52	-0-00-10.48	76.67	0.1
3	1	111	296-10-07.46	0-00-05.96	76.78	0.1
3	2	100	51-28-05.61	0-00-32.61	87.07	0.4
3	2	101	63-49-13.98	0-00-25.48	55.09	0.5
3	2	102	345-49-50.27	-0-00-10.73	89.37	0.1
3	2	103	20-41-39.72	-0-00-10.28	51.78	0.2
3	2	105	31-46-33.77	-0-00-26.73	62.57	0.4
3	2	108	32-24-20.65	0-00-01.15	62.89	0.0
3	2	109	31-21-13.55	0-00-10.55	62.73	0.2
3	2	110	31-35-15.73	-0-00-04.77	62.05	0.1

3	2	111	32-37-17.67	-0-00-02.83	62.20	0.0
2	1	102	43-57-37.47	0-00-02.47	78.75	0.0
2	1	103	289-19-05.18	0-00-02.68	98.29	0.0
2	1	104	338-10-02.25	-0-00-08.75	79.75	0.1
2	1	105	338-05-30.00	-0-00-17.00	80.32	0.2
2	1	106	337-36-16.33	-0-00-06.17	80.24	0.1
2	1	107	337-41-02.99	-0-00-06.01	79.66	0.1
2	1	108	338-42-55.68	0-00-10.68	79.15	0.1
2	1	109	338-31-27.20	-0-00-09.30	81.05	0.1
2	1	110	336-53-56.46	-0-00-03.04	80.78	0.0
2	1	111	337-08-03.53	-0-00-06.47	78.91	0.1
2	3	102	12-43-21.81	-0-00-54.19	82.22	0.7
2	3	103	258-04-49.52	-0-00-04.98	101.09	0.0
2	3	104	306-55-46.58	-0-00-32.42	83.18	0.4
2	3	105	306-51-14.33	-0-00-30.17	83.72	0.4
2	3	106	306-22-00.67	-0-00-16.83	83.64	0.2
2	3	107	306-26-47.33	-0-00-09.17	83.09	0.1
2	3	108	307-28-40.02	-0-00-06.48	82.60	0.1
2	3	109	307-17-11.53	-0-00-23.47	84.42	0.3
2	3	110	305-39-40.80	-0-00-31.70	84.16	0.4
2	3	111	305-53-47.87	-0-00-33.13	82.37	0.4

Adjusted Distance Observations (Meters)

From	To	Distance	Residual	StdErr	StdRes
109	111	0.2241	0.0001	0.0005	0.1
108	110	0.2240	0.0000	0.0005	0.1
109	110	0.1585	-0.0000	0.0005	0.0
110	111	0.1584	-0.0001	0.0005	0.2
111	108	0.1584	-0.0001	0.0005	0.1
108	109	0.1585	-0.0000	0.0005	0.0
105	107	0.0680	-0.0001	0.0005	0.1
104	106	0.0680	-0.0001	0.0005	0.1
104	105	0.0481	0.0000	0.0005	0.0
105	106	0.0481	0.0000	0.0005	0.0
106	107	0.0481	0.0000	0.0005	0.0
107	104	0.0481	0.0000	0.0005	0.0
1	2	13.2613	0.0006	0.0020	0.3
1	3	6.9210	0.0003	0.0020	0.2
1	2	13.2613	0.0006	0.0020	0.3
1	3	6.9210	0.0003	0.0020	0.2
1	2	13.2613	-0.0002	0.0020	0.1
1	3	6.9210	0.0006	0.0020	0.3
3	1	6.9210	0.0006	0.0020	0.3
3	2	10.5609	-0.0006	0.0020	0.3
3	1	6.9210	-0.0002	0.0020	0.1
3	2	10.5609	-0.0003	0.0020	0.2
3	1	6.9210	0.0001	0.0020	0.0
3	2	10.5609	-0.0006	0.0020	0.3
2	1	13.2613	-0.0002	0.0020	0.1
2	3	10.5609	-0.0001	0.0020	0.0
2	1	13.2613	-0.0004	0.0020	0.2
2	3	10.5609	-0.0006	0.0020	0.3
2	1	13.2613	0.0003	0.0020	0.2
2	3	10.5609	-0.0006	0.0020	0.3
1	100	5.0660	0.0009	0.0029	0.3
1	101	6.3977	0.0011	0.0029	0.4
1	102	10.1213	0.0006	0.0029	0.2
1	103	12.6774	0.0005	0.0029	0.2
1	104	8.6398	0.0015	0.0029	0.5
1	105	8.6806	0.0019	0.0029	0.7
1	106	8.7024	0.0024	0.0029	0.8
1	107	8.6614	0.0019	0.0029	0.7
1	100	5.0660	0.0010	0.0029	0.4
1	101	6.3977	0.0012	0.0029	0.4
1	102	10.1213	0.0009	0.0029	0.3

1	103	12.6774	0.0004	0.0029	0.1
1	104	8.6398	0.0022	0.0029	0.7
1	105	8.6806	0.0020	0.0029	0.7
1	106	8.7024	0.0015	0.0029	0.5
1	107	8.6614	0.0010	0.0029	0.3
3	100	5.4538	0.0007	0.0029	0.2
3	101	10.8555	-0.0006	0.0029	0.2
3	102	5.4249	-0.0000	0.0029	0.0
3	103	12.4315	-0.0007	0.0029	0.2
3	105	8.8106	0.0002	0.0029	0.1
3	108	8.5513	-0.0007	0.0029	0.2
3	109	8.5836	-0.0020	0.0029	0.7
3	110	8.7364	-0.0012	0.0029	0.4
3	111	8.7037	-0.0014	0.0029	0.5
3	100	5.4538	-0.0000	0.0029	0.0
3	101	10.8555	-0.0007	0.0029	0.2
3	102	5.4249	0.0004	0.0029	0.1
3	103	12.4315	-0.0008	0.0029	0.3
3	105	8.8106	-0.0031	0.0029	1.1
3	108	8.5513	-0.0011	0.0029	0.4
3	109	8.5836	-0.0021	0.0029	0.7
3	110	8.7364	-0.0012	0.0029	0.4
3	111	8.7037	-0.0014	0.0029	0.5
2	102	5.9682	0.0002	0.0029	0.1
2	103	4.8621	0.0010	0.0030	0.3
2	104	6.1084	0.0022	0.0029	0.8
2	105	6.0643	0.0010	0.0029	0.3
2	106	6.0718	0.0029	0.0029	1.0
2	107	6.1154	0.0027	0.0029	0.9
2	108	5.8807	-0.0016	0.0029	0.6
2	109	5.7276	-0.0033	0.0029	1.1
2	110	5.7491	-0.0007	0.0029	0.2
2	111	5.9002	-0.0015	0.0029	0.5
2	102	5.9682	0.0002	0.0029	0.1
2	103	4.8621	0.0005	0.0030	0.2
2	104	6.1084	0.0032	0.0029	1.1
2	105	6.0643	0.0024	0.0029	0.8
2	106	6.0718	0.0024	0.0029	0.8
2	107	6.1154	0.0022	0.0029	0.7
2	108	5.8807	-0.0002	0.0029	0.1
2	109	5.7276	-0.0022	0.0029	0.8
2	110	5.7491	-0.0012	0.0029	0.4
2	111	5.9002	-0.0001	0.0029	0.0

Adjusted Zenith Observations (DMS)

From	To	Zenith	Residual	StdErr	StdRes
1	2	89-54-18.32	-0-00-00.58	5.00	0.1
1	3	89-54-12.70	0-00-03.10	5.00	0.6
1	2	89-54-18.32	-0-00-02.28	5.00	0.5
1	3	89-54-12.70	-0-00-00.10	5.00	0.0
1	2	89-54-18.32	-0-00-00.38	5.00	0.1
1	3	89-54-12.70	-0-00-03.10	5.00	0.6
3	1	90-05-47.49	-0-00-04.21	5.00	0.8
3	2	89-56-38.53	-0-00-00.87	5.00	0.2
3	1	90-05-47.49	-0-00-01.11	5.00	0.2
3	2	89-56-38.53	-0-00-01.17	5.00	0.2
3	1	90-05-47.49	-0-00-03.61	5.00	0.7
3	2	89-56-38.53	-0-00-03.17	5.00	0.6
2	1	90-05-42.05	0-00-02.95	5.00	0.6
2	3	90-03-21.76	-0-00-04.54	5.00	0.9
2	1	90-05-42.05	-0-00-00.05	5.00	0.0
2	3	90-03-21.76	-0-00-03.34	5.00	0.7
2	1	90-05-42.05	0-00-01.75	5.00	0.3
2	3	90-03-21.76	-0-00-05.54	5.00	1.1
1	100	75-45-30.17	-0-00-13.33	113.52	0.1

1	101	73-50-44.52	0-00-04.12	89.55	0.0
1	102	80-05-57.86	-0-00-18.14	57.43	0.3
1	103	80-48-41.26	-0-00-16.34	46.00	0.4
1	104	73-56-35.99	-0-01-32.21	66.37	1.4
1	105	74-01-31.84	-0-01-32.96	66.07	1.4
1	106	74-03-31.37	-0-01-51.23	65.91	1.7
1	107	73-59-00.14	-0-01-36.26	66.21	1.5
1	100	75-45-30.17	0-00-36.47	113.52	0.3
1	101	73-50-44.52	-0-00-09.28	89.55	0.1
1	102	80-05-57.86	-0-00-55.14	57.43	1.0
1	103	80-48-41.26	-0-00-10.44	46.00	0.2
1	104	73-56-35.99	-0-01-49.41	66.37	1.6
1	105	74-01-31.84	-0-01-44.86	66.07	1.6
1	106	74-03-31.37	-0-02-02.73	65.91	1.9
1	107	73-59-00.14	-0-01-48.66	66.21	1.6
3	100	76-54-56.68	0-00-21.88	105.71	0.2
3	101	80-37-29.41	-0-00-00.09	53.62	0.0
3	102	71-25-09.81	0-00-38.91	104.90	0.4
3	103	80-40-57.23	-0-00-03.57	46.89	0.1
3	105	74-20-45.58	-0-01-24.22	65.15	1.3
3	108	79-43-10.28	0-01-41.68	67.86	1.5
3	109	79-47-24.22	0-02-53.62	67.60	2.6
3	110	79-56-38.96	0-01-14.36	66.45	1.1
3	111	79-54-39.17	0-01-27.77	66.69	1.3
3	100	76-54-56.68	-0-00-20.72	105.71	0.2
3	101	80-37-29.41	0-00-10.61	53.62	0.2
3	102	71-25-09.81	0-00-48.91	104.90	0.5
3	103	80-40-57.23	0-00-02.73	46.89	0.1
3	105	74-20-45.58	-0-01-47.82	65.15	1.7
3	108	79-43-10.28	0-01-28.38	67.86	1.3
3	109	79-47-24.22	0-02-56.92	67.60	2.6
3	110	79-56-38.96	0-01-08.56	66.45	1.0
3	111	79-54-39.17	0-01-21.97	66.69	1.2
2	102	73-16-03.07	0-00-30.07	95.84	0.3
2	103	65-40-47.24	0-00-50.74	114.90	0.4
2	104	67-11-37.76	-0-01-37.34	91.88	1.1
2	105	67-01-32.36	-0-01-28.64	92.47	1.0
2	106	67-02-37.94	-0-01-44.16	92.38	1.1
2	107	67-13-11.93	-0-01-29.97	91.79	1.0
2	108	75-03-46.32	0-01-50.02	97.65	1.1
2	109	74-42-07.09	0-04-43.39	100.14	2.8
2	110	74-43-10.62	0-01-52.62	99.79	1.1
2	111	75-07-39.35	0-01-48.85	97.34	1.1
2	102	73-16-03.07	0-00-30.47	95.84	0.3
2	103	65-40-47.24	0-00-41.24	114.90	0.4
2	104	67-11-37.76	-0-01-33.24	91.88	1.0
2	105	67-01-32.36	-0-01-21.44	92.47	0.9
2	106	67-02-37.94	-0-01-46.26	92.38	1.2
2	107	67-13-11.93	-0-01-31.97	91.79	1.0
2	108	75-03-46.32	0-02-07.42	97.65	1.3
2	109	74-42-07.09	0-04-36.59	100.14	2.8
2	110	74-43-10.62	0-01-45.82	99.79	1.1
2	111	75-07-39.35	0-02-07.55	97.34	1.3

Adjusted Azimuth/Bearing Observations (DMS)

From	To	Bearing	Residual	StdErr	StdRes
103	100	N00-00-00.00W	-0-00-00.00	FIXED	0.0

Adjusted Bearings (DMS) and Horizontal Distances (Meters)

(Relative Confidence of Bearing is in Seconds)

From	To	Bearing	Distance	95% RelConfidence		
				Brg	Dist	PPM
1	2	S32-29-51.57E	13.2613	111.23	0.0012	91.0350
1	3	S84-48-25.71E	6.9210	111.31	0.0007	104.8209
1	100	S34-55-14.58E	4.9103	221.29	0.0033	676.7488
1	101	S25-09-48.29W	6.1451	156.50	0.0036	584.1193
1	102	S55-56-45.42E	9.9705	124.85	0.0027	267.0435
1	103	S12-58-46.84E	12.5147	87.85	0.0026	205.6847
1	104	S17-53-20.34E	8.3028	123.28	0.0018	210.9246
1	105	S18-02-31.78E	8.3454	117.77	0.0022	258.9042
1	106	S17-44-59.62E	8.3677	122.87	0.0018	217.9580
1	107	S17-35-44.28E	8.3252	117.96	0.0024	286.3855
2	3	N01-15-35.91W	10.5609	111.24	0.0010	93.1592
100	3	N50-12-29.70E	5.3122	204.71	0.0034	633.2769
100	103	S00-00-00.00E	8.1688	0.00	0.0040	494.1415
101	3	N62-33-38.07E	10.7105	130.06	0.0034	318.9262
102	2	S11-27-45.90W	5.7155	142.57	0.0029	508.8419
102	3	N15-25-45.64W	5.1422	149.99	0.0028	552.8360
103	2	N76-49-13.61E	4.4307	150.78	0.0035	789.7042
103	3	N19-26-03.80E	12.2675	89.46	0.0027	219.5941
104	2	S54-19-49.33E	5.6308	129.28	0.0021	377.6923
104	105	S45-31-08.56E	0.0481	9320.47	0.0007	15152.4494
104	106	S00-31-04.42E	0.0680	9723.16	0.0006	8828.2419
104	107	S44-28-51.44W	0.0481	9320.46	0.0007	15051.8289
105	2	S54-24-21.58E	5.5833	131.26	0.0019	347.2384
105	3	N30-30-57.85E	8.4838	119.71	0.0020	232.4887
105	106	S44-28-51.44W	0.0481	9320.46	0.0007	15051.8289
105	107	S89-28-47.29W	0.0680	9590.50	0.0006	8828.2422
106	2	S54-53-35.24E	5.5909	127.90	0.0022	397.8463
106	107	N45-31-08.56W	0.0481	9320.47	0.0007	15152.4494
107	2	S54-48-48.59E	5.6384	133.47	0.0020	359.6743
108	2	S53-46-55.89E	5.6820	130.81	0.0024	415.0948
108	3	N31-08-44.73E	8.4140	125.47	0.0018	218.6231
108	109	S47-05-50.98E	0.1584	3131.43	0.0007	4639.7979
108	110	S02-05-44.42E	0.2240	3240.19	0.0006	2695.6546
108	111	S42-54-09.02W	0.1584	3131.43	0.0007	4591.4363
109	2	S53-58-24.38E	5.5247	139.13	0.0022	401.9738
109	3	N30-05-37.63E	8.4477	122.69	0.0023	270.4058
109	110	S42-54-09.02W	0.1584	3131.43	0.0007	4591.4363
109	111	S87-54-02.45W	0.2240	3210.51	0.0006	2695.6556
110	2	S55-35-55.12E	5.5458	134.37	0.0025	450.8355
110	3	N30-19-39.81E	8.6022	126.41	0.0020	227.1712
110	111	N47-05-50.98W	0.1584	3131.43	0.0007	4639.7979
111	2	S55-21-48.05E	5.7026	133.90	0.0023	400.4018
111	3	N31-21-41.75E	8.5691	123.19	0.0021	245.4393



## Error Propagation

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### Station Coordinate Standard Deviations (Meters)

Station	N	E	Elev
2	0.001435	0.001317	0.000672
3	0.001385	0.002004	0.000672
103	0.000000	0.000000	0.001325
100	0.001649	0.000000	0.001551
109	0.001437	0.001577	0.000000
1	0.001188	0.002107	0.000673
101	0.002139	0.001833	0.001555
102	0.001977	0.001609	0.001322
104	0.001188	0.001429	0.001080
105	0.001318	0.001282	0.000999
106	0.001187	0.001442	0.001079
107	0.001374	0.001284	0.001080
108	0.001182	0.001652	0.001083
110	0.001189	0.001805	0.001083
111	0.001315	0.001580	0.001084

### Station Coordinate Error Ellipses (Meters) Confidence Region = 95%

Station	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Elev
2	0.003926	0.002706	38-05	0.001316
3	0.005361	0.002613	117-29	0.001317
103	0.000000	0.000000	0-00	0.002598
100	0.004037	0.000000	0-00	0.003040
109	0.003862	0.003515	92-52	0.000000
1	0.005342	0.002550	72-41	0.001318
101	0.005433	0.004245	25-22	0.003047
102	0.005008	0.003721	157-24	0.002591
104	0.003497	0.002908	90-06	0.002116
105	0.003235	0.003130	163-32	0.001958
106	0.003536	0.002900	95-29	0.002115
107	0.003373	0.003133	168-32	0.002116
108	0.004062	0.002867	97-40	0.002123
110	0.004419	0.002911	90-50	0.002124
111	0.003927	0.003147	106-46	0.002125

### Relative Error Ellipses (Meters) Confidence Region = 95%

Stations From	To	Semi-Major Axis	Semi-Minor Axis	Azimuth of Major Axis	Vertical
1	2	0.007152	0.001206	57-04	0.000177
1	3	0.003735	0.000725	4-42	0.000124
1	100	0.005379	0.003141	69-29	0.002741
1	101	0.004666	0.003585	118-30	0.002749
1	102	0.006038	0.002655	31-53	0.002235
1	103	0.005342	0.002550	72-41	0.002242
1	104	0.004965	0.001744	74-05	0.002085
1	105	0.004766	0.002159	70-52	0.001836
1	106	0.004991	0.001807	75-18	0.002085
1	107	0.004763	0.002381	70-36	0.002086
2	3	0.005696	0.000983	88-21	0.000167
100	3	0.005460	0.003050	121-56	0.002741
100	103	0.004037	0.000000	0-00	0.003540
101	3	0.006756	0.003412	154-14	0.002749
102	2	0.003954	0.002903	105-12	0.002236
102	3	0.003748	0.002831	68-39	0.002235
103	2	0.003926	0.002706	38-05	0.002243

103	3	0.005361	0.002613	117-29	0.002242
104	2	0.003544	0.002101	42-15	0.002085
104	105	0.002174	0.000729	44-58	0.002668
104	106	0.003207	0.000601	89-30	0.002819
104	107	0.002174	0.000724	134-01	0.002819
105	2	0.003576	0.001895	27-52	0.001837
105	3	0.004927	0.001963	122-54	0.001836
105	106	0.002174	0.000724	134-01	0.002667
105	107	0.003163	0.000601	179-28	0.002669
106	2	0.003482	0.002201	42-00	0.002084
106	107	0.002174	0.000729	44-58	0.002818
107	2	0.003686	0.001958	25-28	0.002085
108	2	0.003646	0.002292	47-34	0.002098
108	3	0.005126	0.001817	117-45	0.002098
108	109	0.002405	0.000735	43-26	0.002123
108	110	0.003519	0.000604	88-07	0.002834
108	111	0.002405	0.000727	132-49	0.002835
109	2	0.003744	0.002192	29-16	0.001316
109	3	0.005030	0.002272	123-08	0.001317
109	110	0.002405	0.000727	132-49	0.002124
109	111	0.003487	0.000604	178-04	0.002125
110	2	0.003694	0.002378	50-15	0.002098
110	3	0.005286	0.001916	115-53	0.002098
110	111	0.002405	0.000735	43-26	0.002836
111	2	0.003718	0.002257	27-56	0.002099
111	3	0.005123	0.002090	124-12	0.002099

Elapsed Time = 00:00:04

□30

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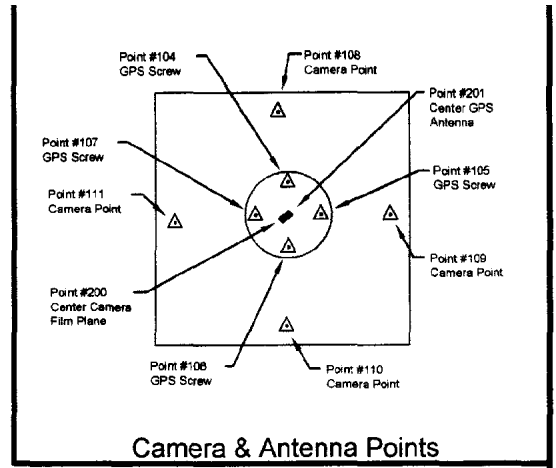
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01 00000397 Adjusted Observations and Residuals  
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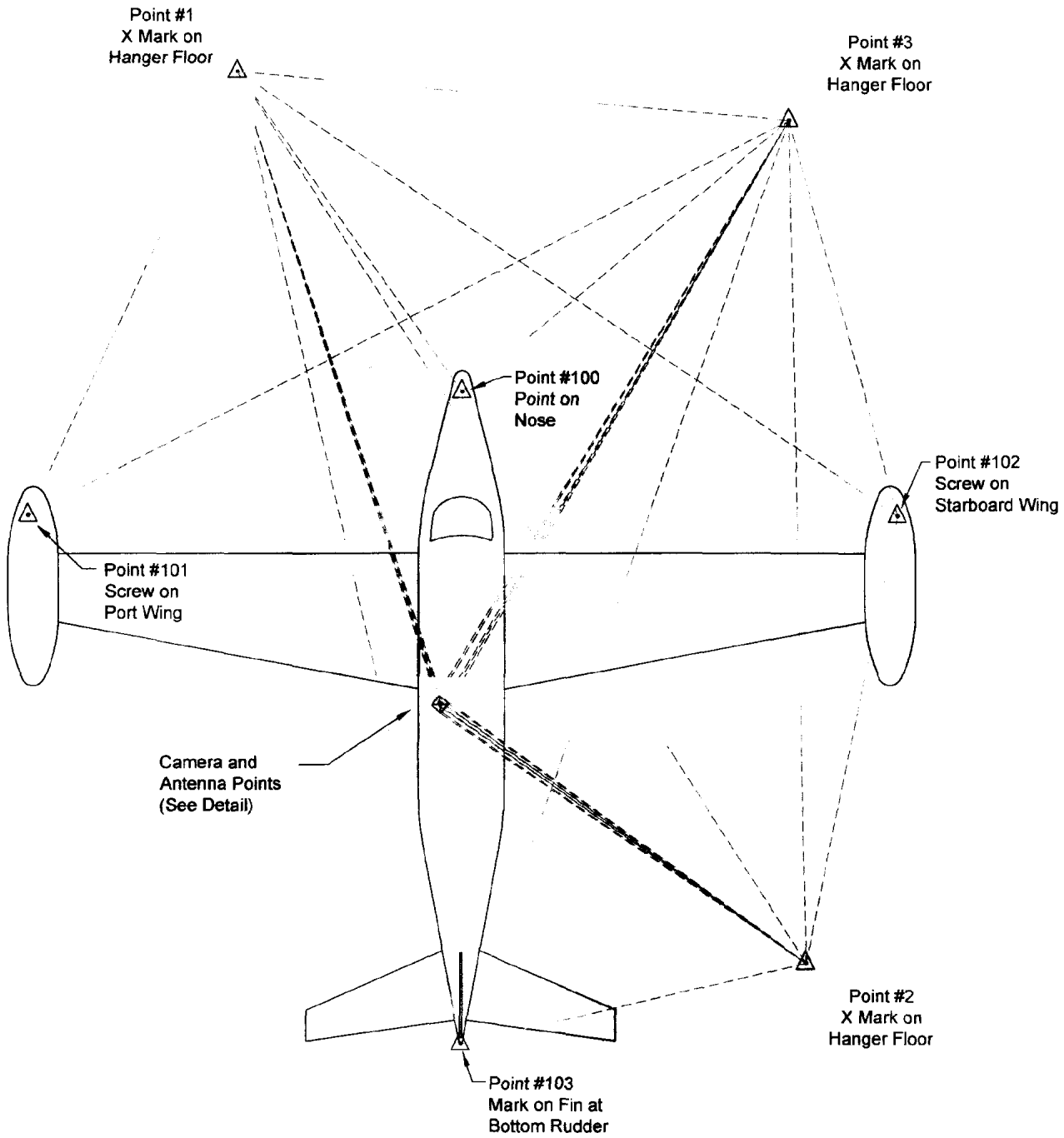
**GEOD**

SURVEYING & AERIAL MAPPING  
Executive Office

18-24 Kancuse Road, Newfoundland, New Jersey 07435



Camera & Antenna Points



Aircraft No. N69622

**Final Coordinates**  
**Project: 1608**  
**Client: Keystone Aerial Surveys**  
**Aircraft: N69622**

**GEOD Corporation**  
**March 22, 2004**

POINT NO.	X Coordinate (Meters)	Y Coordinate (Meters)	Elevation (Meters)	Description
1	-2.8109	12.1950	-1.5332	TR-XCT
2	4.3140	1.0102	-1.5112	TR-XCT
3	4.0818	11.5686	-1.5215	TR-XCT
100	0.0000	8.1688	-0.2869	NOSE POINT
101	-5.4238	6.6331	0.2469	WING POINT
102	5.4498	6.6117	0.2071	WING POINT
103	0.0000	0.0000	0.4912	TAIL POINT
104	-0.2605	4.2936	0.8565	GPS SCREW
105	-0.2261	4.2599	0.8559	GPS SCREW
106	-0.2599	4.2256	0.8570	GPS SCREW
107	-0.2942	4.2593	0.8567	GPS SCREW
108	-0.2701	4.3674	0.0046	CAMERA POINT
109	-0.1541	4.2596	0.0000	CAMERA POINT
110	-0.2619	4.1435	0.0040	CAMERA POINT
111	-0.3780	4.2514	0.0032	CAMERA POINT
200	-0.2660	4.2555	0.0030	CENTER FILM PLANE
201	-0.2602	4.2596	0.8703	CENTER GPS ANT @ TOP DOME

**NOTES:**

The calculated centerline of the GPS antenna is 0.58 cm. starboard of the calculated centerline of the camera film plane.

The calculated centerline of the GPS antenna is 0.41 cm. forward of the calculated centerline of the camera film plane.

The measured elevation of the top of the dome of the GPS antenna is 86.73 cm. higher than the calculated centerline of the camera film plane.