February 13, 2007.

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Project location: Box Canyon, Blind Canyon: Thirty Kilometers Northwest of Twin Falls, Idaho

1. Survey area

The project area consisted of a polygon totally approximately 17 square Km located 30 kilometers northwest of the city of Twin Falls, Idaho. The project area was flown on Monday, December 18, 2006. It required one flight lasting approximately 2.5 hours and required 0.53 hours of laser-on time.

Figure 1 (next page) is an image showing the shape and location of the project areas along with the locations of two GPS reference stations used to support the survey.

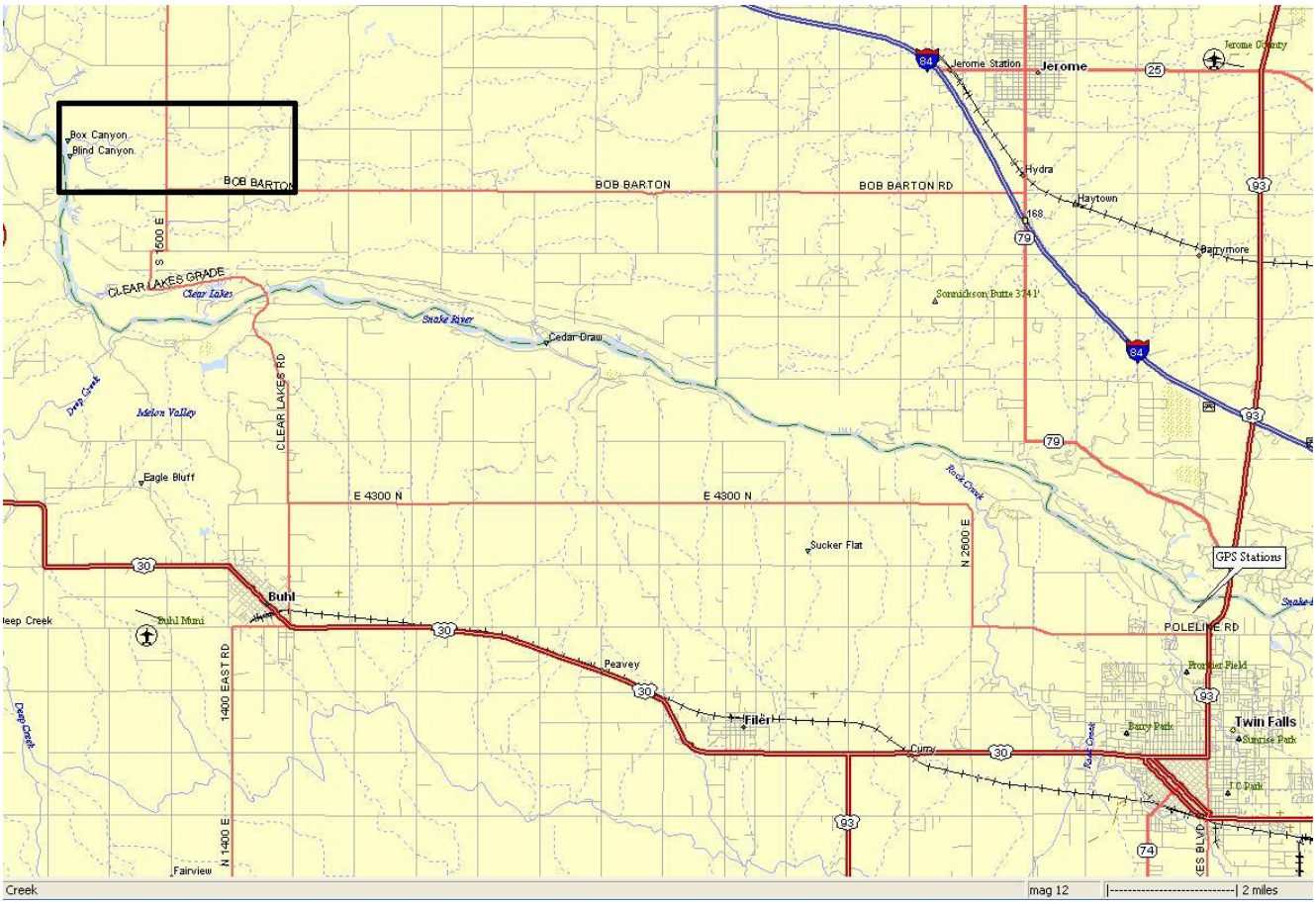

Figure 1 - Project location map: the project polygon is shown in black; test balloon indicates location of two NCALM GPS reference stations.

2. Survey Parameters

These project areas were flown using 11 flight lines oriented east-west and 1 additional cross line for field calibration purposes. The flying height was targeted at 600 meters Above Ground Level (AGL) but varied during the survey from 600 to 700 meters due to the steep terrain. Flying speed was targeted at 60 meters/second (117 knots). The Pulse Rate Frequency of the Optech 2033 ALTM (see http://www.optech.ca/ for more information) used in the survey was 33 KHz. The scan angle was set at +/- 20 degrees, with 0.5 degrees cutoff during processing. The scanning frequency (mirror oscillation rate) was 28 Hz. Point spacing per swath was nominally 1.1 meters along-track at nadir, 2.2 meters along-track at the scan edge and 0.73 meters cross-track. Flight line spacing was set at 215 meters which yielded swath overlap of 100%, (50% sidelap). These survey parameters resulted in approximately 2.5 shots per square meter, before filtering.

3. GPS Reference Stations

Two GPS reference station locations were available for post-processing the trajectory of the aircraft. Both of these receivers were managed by NCALM field personnel. The NCALM station BRIG was set upon the First-Order leveling mark BRIDGE (NGS PID = NV0053). All GPS observations were logged at 1-second and were submitted to the NGS on-line processor OPUS with solution files included as Appendix A. Both BRIG and EDGE logged data for over two hours and the final position was processed (by OPUS) with respect to three CORS stations, ranging from 122 to 168 Km distant. Final coordinates are based on the OPUS solutions. For further information on OPUS see http://www.ngs.noaa.gov/OPUS/ and for more information on the CORS network see http://www.ngs.noaa.gov/CORS/ and http://www.unavco.org/ . NCALM GPS equipment consisted of an ASHTECH (Thales Navigation) Z-Extreme receiver, along with a choke ring antenna (Part# 700936.D) mounted on 1.500-meter fixed-height tripods.

4. Navigation Processing

Airplane trajectories for this survey were processed using KARS software (Kinematic and Rapid Static) written by Dr. Gerry Mader of the NGS Research Laboratory. KARS processing requires dual-frequency carrier phase observations and, in contrast to most commercially-used GPS kinematic processing software, yields a fixed integer (double difference) solution for all 1-second epochs.

For quality assurance purposes the project trajectory was processed separately using two of the reference stations and then coordinate differences between the separate solutions were plotted. Figure 2 (below) is a plot of the component differences in Easting, Northing, and Height of the trajectories as processed from the BRIG and the EDGE.

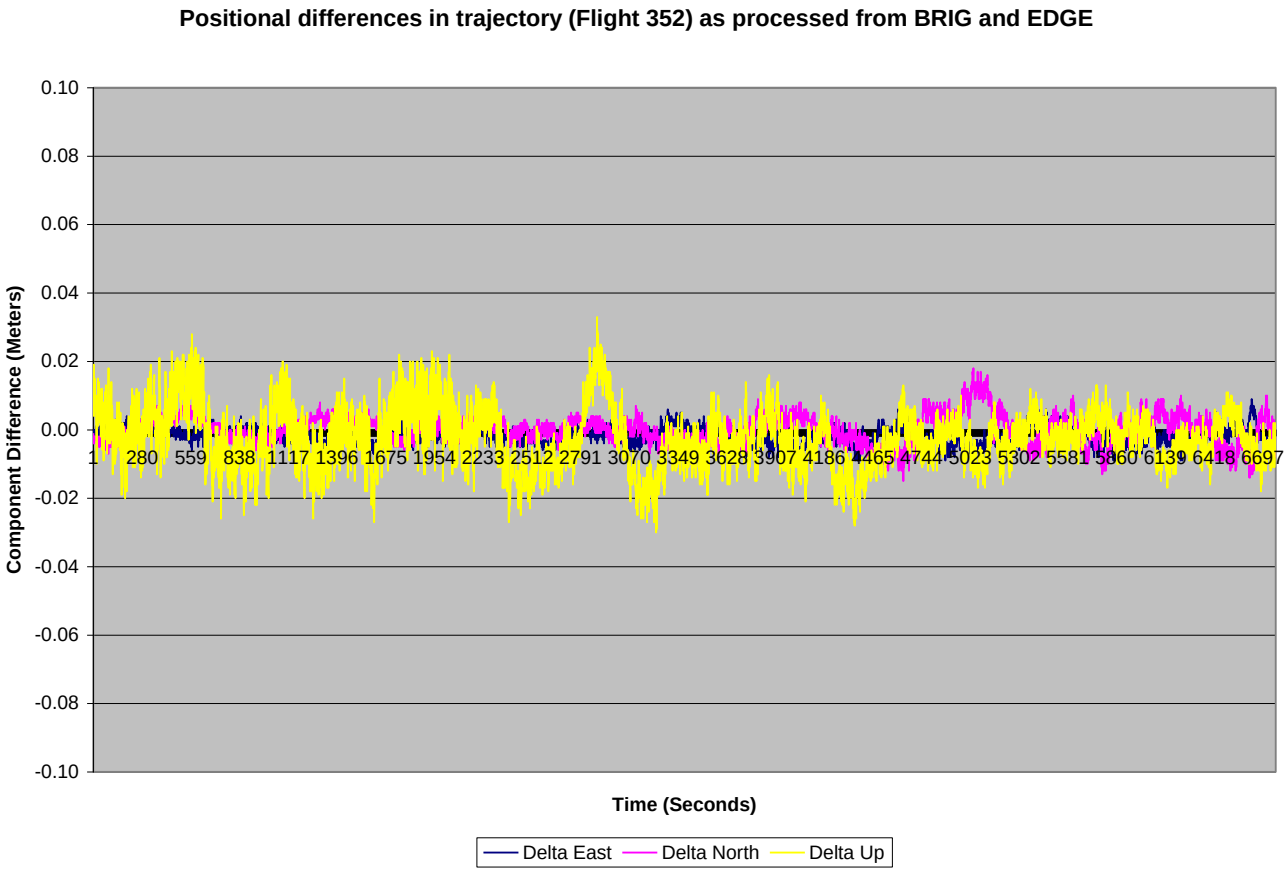

Figure 2 – Positional differences in trajectory positions of the survey flight; these reference stations are 8 m apart and the distance from reference to airplane ranged out to 35 Km from both.

The standard deviation of the trajectory differences is less than 0.004 meters for the horizontal components and less than 0.009 meters for the vertical component. Note that these receivers were only 8 meters apart.

5. Laser Point Processing

After GPS processing was completed for the flight, the final GPS trajectory and the raw IMU (Inertial Measurement Unit) data collected during the flight were input into APPLANIX software POSPROC. This software employs a Kalman Filter algorithm to combine the 1-Hz final differential GPS solution with the raw 50-Hz IMU orientation measurement data and their respective error models. The final result is a smoothed and blended solution of both aircraft position and orientation at 50 Hz, in SBET format (Smoothed Best Estimated Trajectory). The SBET, laser range, and mirror-angle measurement data were combined using Optech's REALM processing suite to generate point clouds in selected calibration areas, usually locations where cross-lines were flown or ground truth was collected.

System calibration was then performed as a 2-step process: step one (relative calibration) is to adjust the bore sight values of heading, roll, pitch, and scanner mirror scale such that systematic positional

errors are minimized; and step two is an absolute calibration such that the laser DEM will match the height values of ground truth collected by vehicle-mounted GPS.

Step 1: Relative calibration was performed in TerraMatch software please see (**http://terrasolid.fi/ENG/Products.htm**) for detailed information.

A general description of the relative calibration procedure follows.

1. Cross-lines are flown for every flight with a heading perpendicular to the project flight line heading.
2. Small polygons containing these cross lines along with project flight lines are processed using approximate calibration values for heading, roll, pitch, and scanner mirror scale. Each line is processed separately.
3. Continuing to process each line separately, all lines are filtered (if necessary) to remove vegetation; then individual flight line surfaces are created.
4. Using TerraMatch, an iterative algorithm is applied to compute the best-fit between the individual flight line surfaces: simultaneously solving for the optimal bore sight values of heading, roll, pitch, and scanner mirror scale.
5. These updated bore sight values are then entered into REALM; new output is produced and checked for all flights.
6. Complete and final output is run using the optimized calibration values for each flight.

The above procedure was run on two areas of the project; calibration values were computed and used to generate final output.

Step 2: Absolute calibration is usually done by comparing the height of the nearest neighbor laser point to the height of a set of check points that are collected by vehicle-mounted GPS. No check points were collected for this project; a typical bias of 0.10 meters was removed from generated output. This bias was noted in the previous project flown (through December 2, 2006) and is typical for many projects processed with KARS trajectories.

All coordinates were processed with respect to NAD83 Reference Frame (CORS96) (EPOCH: 2002.0000). The projection is UTM Zone 10, with units in meters. Heights are referenced to the GRS80 ellipsoid; they have been converted to NAVD88 elevations using the NOAA GEOID03 geoid model.

The most complete output format is a nine-column ASCII (space delimited), one file per flight strip. The nine columns are as follows:

1. GPS time (seconds of week)
2. Easting last stop
3. Northing last stop
4. Height last stop
5. Intensity last stop
6. Easting first stop
7. Northing first stop
8. Height first stop
9. Intensity first stop

Note that the UTM zone code (10) is appended to the Easting coordinate in this five-column format.

During processing, a scan cutoff angle of 0.5 degrees was used to eliminate points at the edge of the scan lines. This was done to improve the overall DEM accuracy (points farthest from the scan nadir are the most affected by small errors in pitch, roll and scanner mirror angle measurements). Points with very low intensity values were also filtered out (intensity values less than 5), because these points also tend to be the least accurate. This is due to the fact that very weak return pulses yield the noisiest range measurements. These points represent a very small percentage of the total number of points, usually in the neighborhood of a few hundredths of one percent.

All calibration files as well as all raw observation files (both GPS and ALTM) necessary to reprocess this project in its entirety are archived by UC Berkeley.

APPENDIX A.

NGS OPUS SOLUTION REPORT

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USER: michaels@ufl.edu DATE: February 01, 2007
RINEX FILE: edge352v.06o TIME: 15:54:56 UTC

SOFTWARE: page5 0612.06 master24.pl START: 2006/12/18 21:56:00
EPHEMERIS: igs14061.eph [precise] STOP: 2006/12/18 23:58:30
NAV FILE: brdc3520.06n OBS USED: 5252 / 5315 : 99%
ANT NAME: ASH700936D_M NONE # FIXED AMB: 27 / 27 : 100%
ARP HEIGHT: 1.500 OVERALL RMS: 0.006(m)

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2006.9643)	
X:	-1946979.752(m)	0.006(m)	-1946980.491(m)	0.006(m)
Y:	-4281092.899(m)	0.017(m)	-4281091.652(m)	0.017(m)
Z:	4295533.434(m)	0.002(m)	4295533.422(m)	0.002(m)
LAT:	42 35 55.74404	0.010(m)	42 35 55.76194	0.010(m)
E LON:	245 32 40.70078	0.013(m)	245 32 40.64863	0.013(m)
W LON:	114 27 19.29922	0.013(m)	114 27 19.35137	0.013(m)
EL HGT:	1081.400(m)	0.009(m)	1080.781(m)	0.009(m)
ORTHO HGT:	1096.632(m)	0.026(m)	[Geoid03 NAVD88]	

	UTM COORDINATES UTM (Zone 11)	STATE PLANE COORDINATES SPC (1102 ID C)
Northing (Y) [meters]	4719404.598	103634.555
Easting (X) [meters]	708759.475	462630.712
Convergence [degrees]	1.72298692	-0.30821949
Point Scale	1.00013621	0.99996454
Combined Factor	0.99996662	0.99979498

US NATIONAL GRID DESIGNATOR: 11TQH0875919405(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
AI5649	GTRG GTRG_EBRY_ID1998 CORS ARP	N431438.711	W1131428.314	122354.6
DG9771	P121 HNSLVALLY_UT2004 CORS ARP	N414812.179	W1124153.795	169921.6
DG6570	IDPO POCATELLO CORS ARP	N425155.995	W1122554.287	168373.9

NEAREST NGS PUBLISHED CONTROL POINT

NV0053	BRIDGE	N423555.707	W1142718.927	8.5

NGS OPUS SOLUTION REPORT

USER: michaels@ufl.edu
RINEX FILE: brig352v.06o

DATE: February 01, 2007
TIME: 15:21:44 UTC

SOFTWARE: page5 0612.06 master22.pl
EPHEMERIS: igs14061.eph [precise]
NAV FILE: brdc3520.06n
ANT NAME: ASH700936D_M NONE
ARP HEIGHT: 1.500

START: 2006/12/18 21:31:00
STOP: 2006/12/19 00:07:00
OBS USED: 6628 / 6635 : 100%
FIXED AMB: 33 / 33 : 100%
OVERALL RMS: 0.006(m)

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2006.9643)	
X:	-1946972.474(m)	0.005(m)	-1946973.213(m)	0.005(m)
Y:	-4281097.129(m)	0.023(m)	-4281095.882(m)	0.023(m)
Z:	4295532.824(m)	0.002(m)	4295532.812(m)	0.002(m)
LAT:	42 35 55.71113	0.013(m)	42 35 55.72902	0.013(m)
E LON:	245 32 41.06814	0.014(m)	245 32 41.01600	0.014(m)
W LON:	114 27 18.93186	0.014(m)	114 27 18.98400	0.014(m)
EL HGT:	1081.603(m)	0.014(m)	1080.985(m)	0.014(m)
ORTHO HGT:	1096.835(m)	0.029(m)	[Geoid03 NAVD88]	

	UTM COORDINATES UTM (Zone 11)	STATE PLANE COORDINATES SPC (1102 ID C)
Northing (Y) [meters]	4719403.835	103633.495
Easting (X) [meters]	708767.878	462639.081
Convergence [degrees]	1.72305577	-0.30815036
Point Scale	1.00013625	0.99996454
Combined Factor	0.99996663	0.99979494

US NATIONAL GRID DESIGNATOR: 11TQH0876819404(NAD 83)

		BASE STATIONS USED		
PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
AI5649	GTRG GTRG_EBRY_ID1998 CORS ARP	N431438.711	W1131428.314	122348.5
DG9771	P121 HNSLVALLY_UT2004 CORS ARP	N414812.179	W1124153.795	169913.8
DG6570	IDPO POCATELLO CORS ARP	N425155.995	W1122554.287	168365.9

		NEAREST NGS PUBLISHED CONTROL POINT		
NV0053	BRIDGE	N423555.707	W1142718.927	0.0

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

8002 The Opus solution for your submitted RINEX file appears to be
8002 quite close to an NGS published control point. This suggests that
8002 you may have set your GPS receiver up over an NGS control point.
8002 Furthermore, our files indicate that this control point has not
8002 been recovered in the last five years.
8002 If you did indeed recover an NGS control point, we would
8002 appreciate receiving this information through our web based
8002 Mark Recovery Form at
8002 http://www.ngs.noaa.gov/products_services.shtml#MarkRecoveryForm.