February 12, 2007.

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Project location: San Jose, California

1. Survey area

The project area consisted of two polygons totally approximately 40 square Km located 30 kilometers west of San Jose, CA. The project area was flown on Wednesday and Thursday, December 6-7, 2006. It required two flights lasting approximately 6 hours (total) and required 1.7 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 polygons are shown in black; text balloon PPT5 points to the location of Pigeon Point, a NOAA Continuously Operating Reference Station (CORS) and text balloon SJC points to the NCALM GPS reference station set up at San Jose International Airport

2. Survey Parameters

These project areas were flown using 55 flight lines oriented northwest-southeast and 4 additional cross lines for field calibration purposes. The flying height was targeted at 600 meters Above Ground Level (AGL) but varied during the survey from 600 to 900 meters due to the mountainous 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 2.7 shots per square meter, before filtering.

3. GPS Reference Stations

Three GPS reference station locations were available for post-processing the trajectory of the aircraft. Two of these (PPT5 and ZOA1) were Continuously Operating Reference Stations (CORS) managed by NOAA logging at 5 seconds and 1 second, respectively; a third GPS reference station was set at the San Jose International Airport and was operated by NCALM. The NCALM GPS observations were logged at 1-second and were submitted to the NGS on-line processor OPUS with solution files included as Appendix A. The NCALM station (SJC_) logged data for over fifteen hours and the final position was processed (by OPUS) with respect to three nearby CORS stations, all less than 25 Km distant. Final coordinates for SJC_ 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 1.950-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 CORS station PPT5 and the NCALM station SJC_. RINEX observations from PPT5 were interpolated to 1-second epochs (from 5-second epochs) by the NGS program interpo.exe – see http://www.ngs.noaa.gov/CORS/Utilities/Interpo/Dos/interpo.txt for more information.

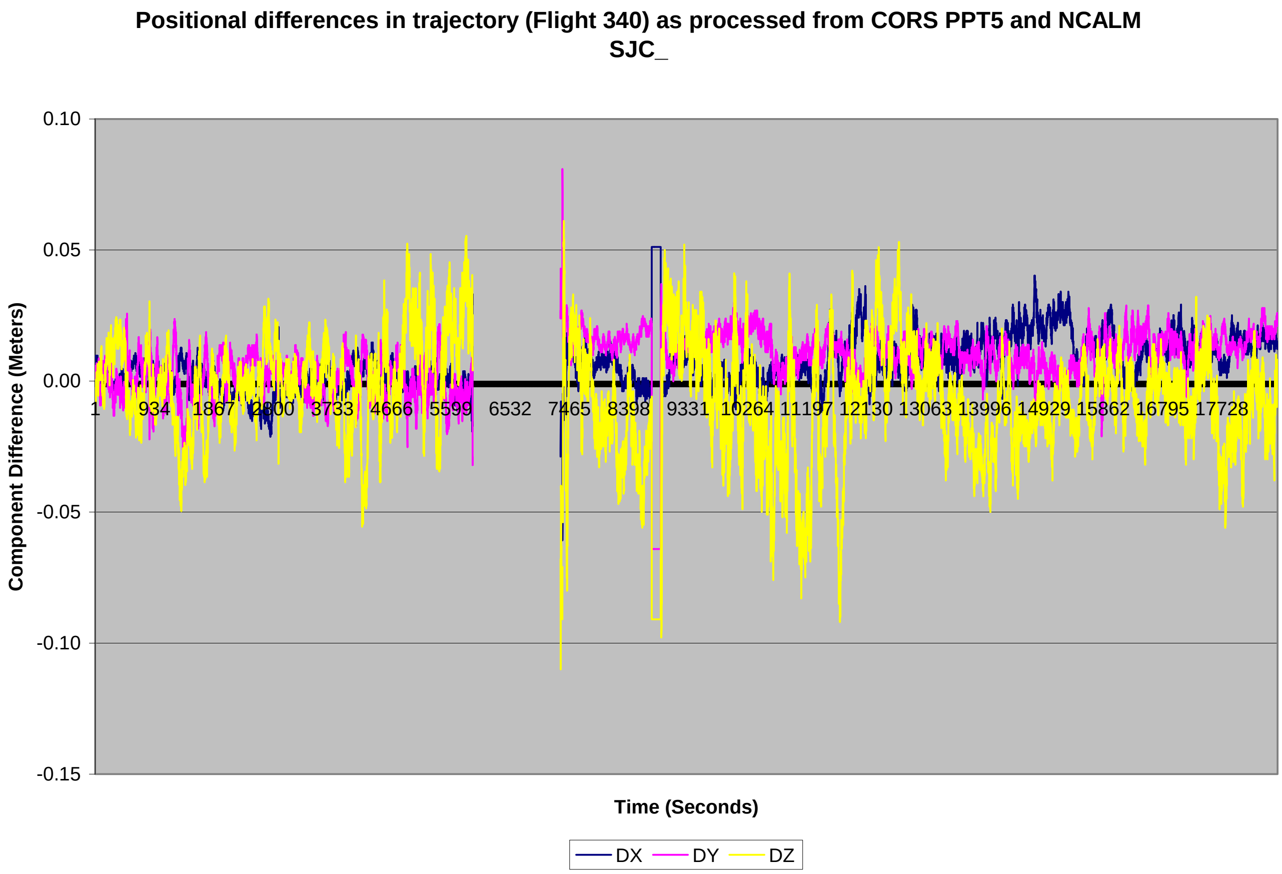


Figure 2 – Positional differences in trajectory positions of the survey flight; these reference stations are 46 Km apart and the distance from reference to airplane ranged out to 30 Km from PPT5 and out to 35 Km from SJC_.

The standard deviation of the trajectory differences is less than 0.019 meters for the horizontal components and less than 0.039 meters for the vertical component.

A disruption of the GPS signal occurred during the survey flight of December 6th (day 340) which affected all logged data in the aircraft and on the ground both at the NCALM station and the CORS. This resulted in a loss of good quality GPS from 19:17 – 19:40 GMT and degraded quality for several more minutes following reacquisition of all satellites - several lines were lost. These lines were re-flown on December 7 (day 341). The cause of the disruption is unknown; it can be noted as untypical noise in Figure 2 occurring in the epochs leading up the break and in the 20 minutes following the break.

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.

6. Bare-earth filtering

Terrasolid's TerraScan (http://terrasolid.fi) software was used to classify the last return LIDAR points and generate the "bare-earth" dataset.

The bare-earth filtering macro consists of the following routines:

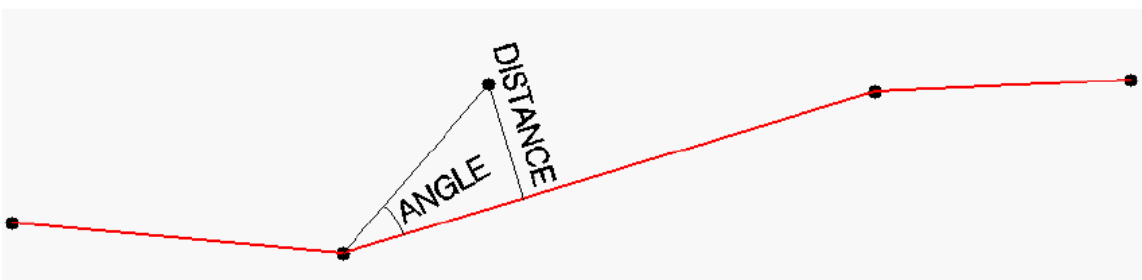
1) Removal of "Low Points". This routine was used to search for possible error points which are clearly below the ground surface. The elevation of each point (=center) is compared with every other point within a given neighborhood and if the center point is clearly lower then any other

point it will be classified as a “low point”. This routine can also search for groups of low points where the whole group is lower than other points in the vicinity. The parameters used on this dataset were:

Search for: Groups of Points
Max Count (maximum size of a group of low points): 6
More than (minimum height difference): 0.5 m
Within (xy search range): 5.0 m

2) Ground Classification. This routine classifies ground points by iteratively building a triangulated surface model. The algorithm starts by selecting some local low points assumed as sure hits on the ground, within a specified windows size. This makes the algorithm particularly sensitive to low outliers in the initial dataset, hence the requirement of removing as many erroneous low points as possible in the first step.

The routine builds an initial model from selected low points. Triangles in this initial model are mostly below the ground with only the vertices touching ground. The routine then starts molding the model upwards by iteratively adding new laser points to it. Each added point makes the model follow ground surface more closely. Iteration parameters determine how close a point must be to a triangle plane so that the point can be accepted to the model. **Iteration angle** is the maximum angle between point, its projection on triangle plane and closest triangle vertex. The smaller the Iteration angle, the less eager the routine is to follow changes in the point cloud. **Iteration distance** parameter makes sure that the iteration does not make big jumps upwards when triangles are large. This helps to keep low buildings out of the model. The routine can also help avoiding adding unnecessary point density into the ground model by reducing the eagerness to add new points to ground inside a triangle with all edges shorter than a specified length.



Ground classification parameters used:

Max Building Size (window size): 60.0 m
Terrain Angle: 88.0
Iteration Angle: 6.2
Iteration Distance: 5.0 m
Reduce iteration angle when edge length < : 5.0 m

3) Below Surface removal. This routine classifies points which are lower than other neighboring points and it is run after ground classification to locate points which are below the true ground

surface. For each point in the source class, the algorithm finds up to 25 closest neighboring source points and fits a plane equation through them. If the initially selected point is above the plane or less than “Z tolerance”, it will not be classified. Then it computes the standard deviation of the elevation differences from the neighboring points to the fitted plane and if the central point is more than “Limit” times standard deviation below the plane, the algorithm it will classify it into the target class.

Below Surface classification parameters used:

```
Source Class: Ground
Target Class: Low Point
Limit: 8.00 * standard deviation
Z tolerance: 0.10 m
```

APPENDIX A.
GPS Reference Station Coordinates from OPUS

```
                         NGS OPUS SOLUTION REPORT
                         ========================

      USER: michaels@ufl.edu                          DATE: December 08, 2006
RINEX FILE: sjc_340p.06o                              TIME: 00:29:23 UTC


  SOFTWARE: page5  0601.10 master31.pl               START: 2006/12/06  15:56:00
 EPHEMERIS: igr14043.eph [rapid]                      STOP: 2006/12/06  23:26:00
  NAV FILE: brdc3400.06n                          OBS USED: 14495 / 15254   :  95%
  ANT NAME: ASH700936D_M    NONE               # FIXED AMB:    68 /    68   : 100%
ARP HEIGHT: 1.950                              OVERALL RMS: 0.011(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)           ITRF00 (EPOCH:2006.9310)

         X:     -2683717.930(m)   0.008(m)          -2683718.709(m)   0.008(m)
         Y:     -4308375.028(m)   0.017(m)          -4308373.670(m)   0.017(m)
         Z:      3849187.135(m)   0.011(m)           3849187.204(m)   0.011(m)

       LAT:   37 21 34.62851      0.002(m)        37 21 34.64487      0.002(m)
     E LON:  238  4 51.32394      0.006(m)       238  4 51.26789      0.006(m)
     W LON:  121 55  8.67606      0.006(m)       121 55  8.73211      0.006(m)
    EL HGT:           -7.725(m)   0.021(m)                -8.272(m)   0.021(m)
 ORTHO HGT:           24.862(m)   0.033(m) [Geoid03 NAVD88]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 10)         SPC (0403 CA 3)
Northing (Y) [meters]     4135315.246           596354.306
Easting (X)  [meters]      595722.981          1874293.781
Convergence  [degrees]     0.65597114          -0.86880421
Point Scale                0.99971287           0.99995238
Combined Factor            0.99971408           0.99995359

US NATIONAL GRID DESIGNATOR: 10SEG9572335315(NAD 83)



                         BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DH9021 P222 COYOTHILLSCN2004 CORS ARP      N373221.244 W1220459.691   24666.3
DE6356 ZOA2 OAKLAND 2 CORS ARP             N373234.873 W1220057.154   22083.6
AF9702 MHCB MT HAMILTON BARD CORS ARP      N372029.501 W1213833.227   24616.8

                 NEAREST NGS PUBLISHED CONTROL POINT
HS4938      AIRPORT BCN SAN JOSE MUN APT   N372150.185 W1215525.522     634.7
```

NGS OPUS SOLUTION REPORT

```
      USER: michaels@ufl.edu                        DATE: February 01, 2007
RINEX FILE: sjc_341q.06o                            TIME: 14:49:28 UTC


  SOFTWARE: page5  0612.06 master4.pl             START: 2006/12/07  16:15:00
 EPHEMERIS: igs14044.eph [precise]                 STOP: 2006/12/07  23:58:30
  NAV FILE: brdc3410.06n                       OBS USED: 15753 / 16092   :  98%
  ANT NAME: ASH700936D_M    NONE             # FIXED AMB:    53 /    53   : 100%
ARP HEIGHT: 1.950                            OVERALL RMS: 0.011(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2006.9338)

         X:     -2683717.927(m)   0.010(m)          -2683718.706(m)   0.010(m)
         Y:     -4308375.032(m)   0.008(m)          -4308373.674(m)   0.008(m)
         Z:      3849187.127(m)   0.005(m)           3849187.196(m)   0.005(m)

       LAT:   37 21 34.62827      0.002(m)        37 21 34.64463      0.002(m)
     E LON:  238  4 51.32413      0.009(m)       238  4 51.26808      0.009(m)
     W LON:  121 55  8.67587      0.009(m)       121 55  8.73192      0.009(m)
    EL HGT:           -7.729(m)   0.011(m)                -8.276(m)   0.011(m)
 ORTHO HGT:           24.858(m)   0.027(m) [Geoid03 NAVD88]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 10)         SPC (0403 CA 3)
Northing (Y) [meters]     4135315.239           596354.299
Easting (X)  [meters]      595722.986          1874293.786
Convergence  [degrees]     0.65597117          -0.86880418
Point Scale                0.99971287           0.99995238
Combined Factor            0.99971408           0.99995359

US NATIONAL GRID DESIGNATOR: 10SEG9572335315(NAD 83)


                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DH9021 P222 COYOTHILLSCN2004 CORS ARP      N373221.244 W1220459.691   24666.4
DE6356 ZOA2 OAKLAND 2 CORS ARP             N373234.873 W1220057.154   22083.7
AF9702 MHCB MT HAMILTON BARD CORS ARP      N372029.501 W1213833.227   24616.8

                 NEAREST NGS PUBLISHED CONTROL POINT
HS4938      AIRPORT BCN SAN JOSE MUN APT   N372150.185 W1215525.522     634.7
```