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Final Report

Nez Perce National Forest, Clear Creek LiDAR Project

Field and Office Equipment and Software

Field Equipment:

Aircraft: Turbo Prop Cessna 207
LiDAR Sensor: Leica ALS60 200 KHz, multi pulse LiDAR sensor
Camera: Leica RCD 105 digital frame camera with 60mm lens
GPS Survey: Trimble R7 with Zephyr Geodetic Model 2 antenna and Trimble R8 w integrated antenna and receiver, both GLONASS capable

Software:

Trimble Business Center: GPS post processing
Leica IPAS: GPS and IMU data integration
Leica post processor: Raw LiDAR data processing and projection
Terrascan and Microstation: Auto Filtering (Classification)
Inpho Ortho Master & OrthoVista: Ortho processing
Earth View™: LiDAR calibration, analysis, point classification/editing

Airborne Differential GPS Base Station Support:

A Trimble R7 and Zephyr geodetic model 2 antenna was set up on a tripod at the Grangeville, ID airport for the purpose of 0.5 second epoch differential GPS corrections in support of the aerial LiDAR missions or flights. The location used was an arbitrary position, marked with a survey nail and flagging, set next to the taxiway with a 360 degree view of the sky at less than 10 degree elevation mask, and was subsequently 'tied' into the CORS station IDNP that operates at the Grangeville airport with an epoch rate of one second. Once corrected or 'tied' to the IDNP CORS station and observed over the length of time of the project, the position of the nail became as accurate as a first order control point, the highest level of confidence possible.

GPS Ground Control Survey Collection:

Utilizing the Trimble R8 integrated receiver and antenna mounted on a 6.75 foot survey rod, control points were collected to validate the absolute accuracy of the calibrated LiDAR surface. The points were collected at positions that did not have ground obstructions, were on constant slopes, and had enough sky visibility to yield a PDOP (position dilution of precision) of 2.0 or better. Each point was occupied for a minimum of 20 minutes, producing an accuracy equal to or better than third order control. Every effort was made to ensure that the control points were distributed well throughout the project and that the requirement of three control points collected at low, medium and high terrain positions was met. In total, 26 control points were collected with accompanying images of the point's surrounding environment and notes recording average PDOP level and number of satellites in view. Trimble Business Center was then used to post process the control points, utilizing the CORS station IDNP for the differential corrections.

Flight Operations Sensor Parameters:

LiDAR and imagery collection SORTIES we executed from the Pulman/Moscow airport in Washington due to the need for oxygen support, or from the Grangeville airport when the onboard oxygen was sufficient for the anticipated duration of the mission. A Cessna 207, was flown at 14,500 feet above mean sea level with an air speed of 80 knots. The LiDAR sensor was set at 69,400 Hz pulse rate in multi-pulse mode with 12 degrees field of view (+/- 6 deg) and a scan rate of 34 Hz, resulting in a planned minimum swath width of 803 meters (at highest terrain elevation). The maximum flight line spacing was 370 meters, which ensured greater than 50% side lap so as to produce the required shot density of 4 points per square meter. The diameter of each LiDAR pulse foot print was equal to or less than 0.85 meters, and the signal to noise ratio was 13 at 100% system power.

Data Collection Chronology:

10/14/2009: Collection of GPS control points 2 through 7, which were along road 650. Point number 1 had an unacceptable PDOP level and had to be excluded.

10/15/2009: Collection of GPS control points 8 through 16, which were primarily on the northern and eastern boundaries of the project, some points being in the highest areas of the project area.

10/16/2009: LiDAR and imagery collection of 17 flight lines. For the purposes of imagery collection, we flew lines 1, 5, 10, 15, etc. to line 55. Since the imagery foot print covered a large area as compared to the LiDAR, every fifth line sufficed to cover the required side lap between images. It was also important to fly these in the same mission so the imagery would be as radiometrically consistent as possible. We then collected lines 51 - 54. The results of the GPS post processing showed a combined separation value less than 0.1m (forward processing in time as compared to backwards) and a maximum PDOP level of 2.3, both of which are considered excellent.

10/17/2009: Two missions flown for the collection of 17 LiDAR lines. Lines collected were 29 through 49, excluding previously collected lines 30, 35, 40, and 45. For the first mission, the combined separation value was below 0.1m and the maximum PDOP was below 2.3. For the second, the combined separation value was below 0.1m and the maximum PDOP was below 2.9. During the flight, control points 17 through 23 were collected, but point 21 had to be deleted due to battery failure. The area collected was primarily along the closed section of road 286, south of the split from 9730.

10/20/2009: Collection of GPS control points 25 through 29, which were primarily in the lowest areas of the project that could be accessed. These included a clearing to the north of road 650 at the project boundary, and two positions east of Crane Hill, south of Big Cedar.

10/25/2009: Two missions flown for the collection of 29 LiDAR flight lines. The lines collected were 2 through 28, excluding previously collected lines 5, 10, 15, etc. Also, some of these lines were flown twice due to clouds being in the first version (22, 23, 24, 26, 27, and 28). For the first mission, the combined separation value was below 0.05m and the average PDOP was around 2.0, with one spike at 3.0. For the second, the combined separation value was below 0.08m and the maximum PDOP was below 1.6.

LiDAR Post Processing Workflow: (Calibration)

After the completion of a mission, the GPS data from the plane and base station was integrated with the sensor's inertial data from the IMU (inertial measurement unit) and the raw scan data, producing LiDAR data in LAS format utilizing Leica's IPAS software and Leica's LiDAR post processor. The calibration techniques utilized during this process ensured systematic biases were minimized to the maximum extent possible from offset errors in the IMU (roll, pitch, and heading) or from the sensor (swath width, edge curl, intensity differences, ranging biases). These techniques were accomplished manually utilizing Earth Eye Earth View™ software, ensuring the highest accuracy possible for the relative surface adjustment process. Once calibrated the combined DSM was adjusted to the high order control network for a zero bias to compute the final RMSEz accuracy report which yielded an RMSEz of 0.044m as shown in Table 1

Accuracy Assessment:

Note: Final accuracy exceeded the project specification of 15cm with better that 5cm overall.

Table 1

Name	X	Y	Z	Z TIN	Delta	D Square
NP_02	591748.4	5096383	1092.654	1092.652	0.0021	0.00000441
NP_03	591700.9	5096279	1134.543	1134.529	0.0144	0.00020736
NP_04	593463.1	5096278	1187.733	1187.809	-0.0756	0.00571536
NP_05	593907.3	5095627	1211.145	1211.207	-0.0617	0.00380689
NP_06	594690.3	5095809	1283.068	1283.071	-0.0027	0.00000729
NP_07	589841.8	5093509	1370.128	1370.149	-0.021	0.000441
NP_08	597810.6	5104906	1273.138	1273.18	-0.0418	0.00174724
NP_09	599044.4	5104997	1229.1	1229.052	0.0483	0.00233289
NP_10	599450.5	5104724	1224.542	1224.593	-0.0511	0.00261121
NP_11	598282.2	5105389	1273.178	1273.208	-0.0299	0.00089401
NP_12	601206.2	5105407	1339.813	1339.791	0.0216	0.00046656
NP_13	603617.6	5102738	1414.6	1414.625	-0.025	0.000625
NP_14	604439.5	5101211	1608.666	1608.593	0.0731	0.00534361
NP_15	602400.8	5096212	1733.81	1733.805	0.0049	0.00002401
NP_16	601765.2	5093880	1597.179	1597.151	0.0281	0.00078961
NP_17	593358.1	5101305	1118.363	1118.337	0.0256	0.00065536
NP_18	603812.2	5103115	1381.88	1381.857	0.0233	0.00054289
NP_19	601094	5099391	1413.118	1413.08	0.0384	0.00147456
NP_20	600928.8	5099303	1413.09	1413.06	0.0298	0.00088804
NP_22	598052.4	5098862	1291.56	1291.449	0.111	0.012321
NP_23	600055.3	5096961	1341.754	1341.709	0.045	0.002025
NP_25	590851.3	5097681	980.342	980.3496	-0.0076	0.00005776
NP_26	590714.1	5097264	966.47	966.4511	0.0189	0.00035721
NP_27	591720.6	5100740	1012.797	1012.796	0.0015	0.00000225
NP_28	591484.1	5100597	964.417	964.3825	0.0345	0.00119025
NP_29	591894.5	5101498	961.952	962.0195	-0.0675	0.00455625
					Average	0.001887962
					RMSEz	0.0435

LiDAR Point Cloud Classification:

Once the LiDAR data was calibrated and adjusted vertically to the control network, classification was conducted to establish the ground model. Terrascan, running in Microstation, provided the auto classification algorithms that defined the ground surface, based on specific rules respectful of the terrain realities in the project area. Since anomalies remain in any auto generated surface, hand edits were done in Earth View to remove these artifacts. The classifications that the data was assigned to included ground points (class 2), low points (class 7), and canopy (all above ground features, class 5).

Tile Scheme:

Since a specific tile scheme was not specified for project deliverables, an arbitrary 1000m x 1000m tile layout was created for the auto filter and terrain editing steps for production.

Deliverables

1. Tiled Bald earth and canopy classified LiDAR point cloud (las format)
2. Unclassified point cloud by flight line (las format)
3. Color Digital Orthophotography (ecw format)
4. Tile Scheme - (Shapefile format)
5. Survey control (csv format)
6. Survey report (csv format)
7. EarthView™ Software (Waiting for licensed user TBD)
8. Final Report