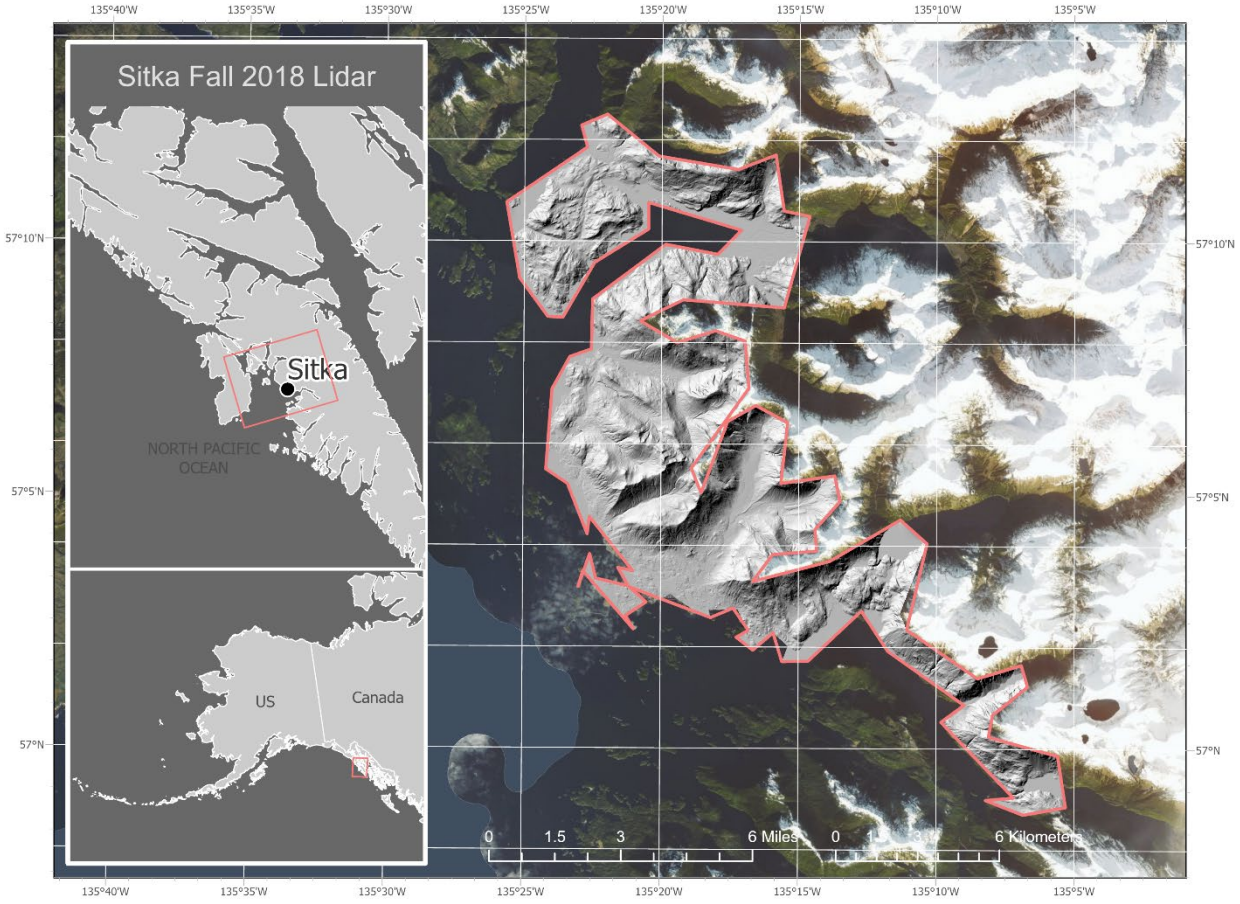
LIDAR-DERIVED ELEVATION DATA FOR SITKA, ALASKA

Ronald P. Daanen, Gabriel J. Wolken, and Andrew M. Herbst

Raw Data File 2020-13



Location map of survey area with ortho-image base layer.

This report has not been reviewed for technical content or for conformity to the editorial standards of DGGS.

2020
STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

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Ronald P. Daanen[1], Gabriel J. Wolken[1], and Andrew M. Herbst[1]

ABSTRACT

The State of Alaska Division of Geological & Geophysical Surveys (DGGS) produced airborne lidar-derived elevation data for Sitka, Alaska. This data collection is being released as a Raw Data File with an open end-user license. All files can be downloaded, free of charge, from the DGGS website at https://doi.org/10.14509/30531.

INTRODUCTION

These data were produced to assess bare earth slope conditions as part of an overarching, multi-hazard risk analysis for the study area, coordinated through the Federal Emergency Management Agency (FEMA) Cooperating Technical Partners (CTP) program. The project was initiated in response to a tragic debris flow incident that took three Alaskans' lives in 2015.

LIST OF DELIVERABLES

Classified Points

Canopy Height Model (CHM)

Digital Terrain Model (DTM)

Digital Surface Model (DSM)

Lidar Intensity Image

Metadata

MISSION PLAN

Airborne Survey Details

This dataset includes point cloud data, a digital terrain model (DTM), digital surface model (DSM), canopy height model (CHM), and an intensity image covering Sitka, Alaska, and the surrounding area (approximately 60 mi^2 [155 km^2]). This survey was conducted with a Riegl VUX1-LR lidar scanner with an integrated GNSS and Northrop Grumman IMU system. The integration was designed by Phoenix LiDAR systems. This survey was flown with a pulse rate between 200,000–400,000 pulses/second and at a scan rate between 80 and 150 revolutions/second. This survey was flown with an average elevation of 400 m above ground level and a ground speed of approximately 40 m/s with a fixed-wing Cessna 185 aircraft. The scan angle was set from 55 to 305 degrees, centered normal to the aircraft's bottom.

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Weather Conditions and Flight Times

Airborne and ground surveys occurred between the 27th and 30th of April, 2018. Weather was partially cloudy throughout the survey, at times obscuring higher altitude topography in the study area. These conditions limited data coverage to areas below 980 meters elevation.

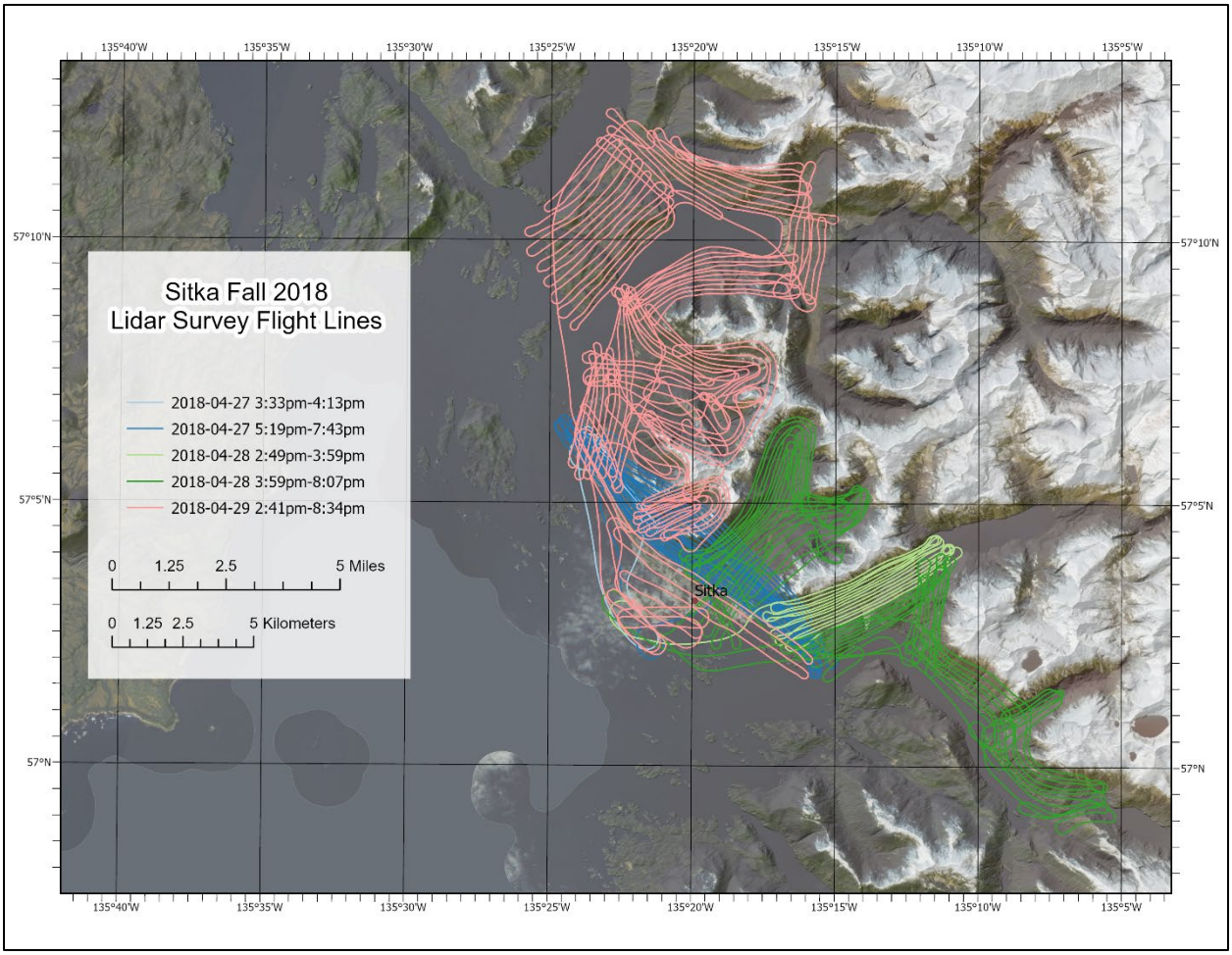

Figure 1. Project flightlines.

PROCESSING REPORT

Lidar Dataset Processing

SDCImport software was used to apply range thresholding, reflectance thresholding, and missed-time-around (MTA) disambiguation for preliminary point cloud noise filtering. In-flight IMU and GNSS data were coupled using Inertial Explorer software to produce the trajectory data. Spatial Explorer software was used to couple the trajectory data with the point cloud.

The point cloud data were calibrated using tielines for roll, pitch, and yaw of the aircraft during the survey. This process was first run using all points, then on a per-flightline basis for

additional accuracy. Interswath fluctuations in ground points were identified using overlapping tielines to further calibrate the data. The point cloud was classified in accordance with American Society for Photogrammetry and Remote Sensing (ASPRS) guidelines using project-tailored macros. Misclassified points were manually reclassified in post-processing QA/QC. The point cloud was converted from ellipsoidal to orthometric heights using geoid 12B, then uniformly adjusted to maintain a mean offset of 0 with collected ground control. Calibration, classification, and height adjustments were all executed in TerraSolid.

Derived products were processed in ArcMap. DTM and DSM were produced using point triangulation with nearest-neighbor interpolation. The DTM was derived from all returns for ground classified points, while the DSM used first returns for all non-noise classes. The CHM was created by subtracting DTM height values from DSM height values. A lidar intensity image was created from first returns of all classes using mean binning.

Lidar Intensity Image

The lidar intensity image includes a range of values between 30.6k and 33.6k and describes the relative amplitude of received signals in the point cloud. Lidar intensity is largely a function of scanned object reflectance in relation to the signal frequency and is not necessarily consistent between separate scans. The intensity image is a single-band, 32-bit float GeoTIFF file with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038 (32-bit, floating-point minimum).

Canopy Height Model

The CHM displays vegetation heights as the difference between DSM and DTM heights. The CHM is a single-band, 32-bit float GeoTIFF file with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038. Note: there are some negative values in the CHM, present in low confidence areas of the DSM and DTM.

Digital Terrain Model

The DTM represents elevations of the ground surface by penetrating or flattening any vegetation, bridges, buildings, etc. The DTM is a single-band, 32-bit float GeoTIFF file with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038.

Digital Surface Model

The DSM represents human-observable surface elevations, which include vegetation, buildings, etc. The DSM is a single band, 32-bit GeoTIFF file with a ground sample distance of 0.5 meters. No Data value is set to -3.40282306074e+038.

Classified Point Cloud

Classified point cloud data is provided in this collection in compressed .laz format. An average point spacing of 0.15 meters was calculated from all returns and all non-noise classes.

SURVEY REPORT

Ground Survey Details

Trimble R8 and R9 RTK GPS systems were used to collect 195 survey points, 100 of which were used as control points and 95 of which were used as checkpoints. Points were gathered by vehicle along the road system and by boat along the coastline. Points were adjusted for accuracy according to OPUS corrections in Trimble Business Center.

Coordinate system and Datum

All data were processed and delivered in NAD83 UTM8N and vertical datum NAVD88, GEOID12B.

Vertical Accuracy

One hundred ground control points were used to determine a -0.015 m average offset from the point cloud (appendix 1), which was corrected with a uniform z-transformation of the lidar data. Point cloud accuracy was measured using 95 checkpoints to determine a root-mean-square error of 0.063 m for the project (appendix 2). Relative accuracy for this dataset has been evaluated as the interswath consistency, measured by comparing tie line points within swath overlap areas. The interswath root-mean-square error was calculated to be 0.008 m.

ACKNOWLEDGMENTS

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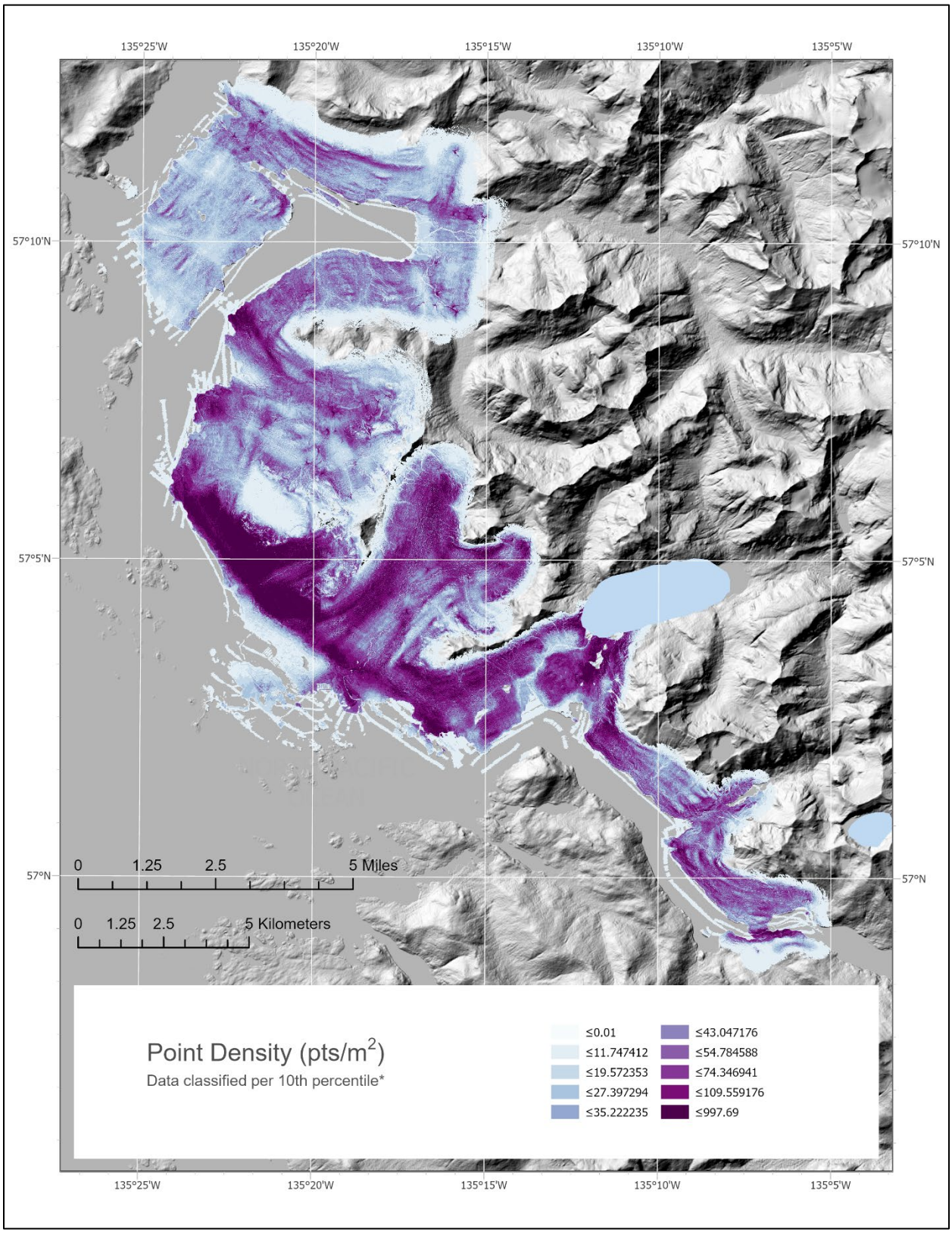

Figure 2. Ground point density displayed as 1-meter raster for the survey.

Appendix 1. Control Points

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-1	484645.2	6321154	26.221	26.24	0.019
gcp-3	484888.8	6321141	21.967	22.01	0.043
gcp-5	484957.2	6321237	15.923	15.97	0.047
gcp-7	485002.1	6321343	12.151	12.2	0.049
gcp-9	485111.2	6321425	10.418	10.43	0.012
gcp-11	485224.2	6321532	8.183	8.19	0.007
gcp-13	485323	6321655	8.646	8.7	0.054
gcp-15	485509.6	6321717	11.955	11.85	-0.105
gcp-17	487755.5	6322435	10.901	10.93	0.029
gcp-19	487766.4	6322440	11.192	11.31	0.118
gcp-21	485931.6	6323021	14.301	14.34	0.039
gcp-23	485878.9	6322963	15.377	15.43	0.053
gcp-25	485849.9	6322873	14.096	14.01	-0.086
gcp-27	485853.8	6322734	10.466	10.4	-0.066
gcp-29	485509.6	6321717	11.924	11.85	-0.074
gcp-31	483340.7	6321938	43.297	43.26	-0.037
gcp-33	483294.9	6321980	44.145	44.14	-0.005
gcp-35	481872.6	6322713	7.532	7.5	-0.032
gcp-37	481328.7	6323880	22.854	22.86	0.006
gcp-39	481041.9	6324038	36.103	36.08	-0.023
gcp-41	479915.6	6323625	12.02	12.02	0
gcp-43	478971.4	6324535	29.73	29.73	0
gcp-45	478967.7	6324501	29.339	29.35	0.011
gcp-47	478939.4	6324730	27.882	27.91	0.028
gcp-49	478944.6	6324762	28.851	28.83	-0.021
gcp-51	478120.8	6325871	59.968	59.93	-0.038
gcp-53	476434.6	6328664	55.13	55.18	0.05
gcp-55	475833.8	6329480	9.747	9.73	-0.017
gcp-59	478029.1	6322993	8.563	8.56	-0.003
gcp-61	478087.2	6322977	7.739	7.73	-0.009
gcp-63	476656	6327884	45.875	45.82	-0.055
gcp-65	476842.5	6327692	42.003	41.94	-0.063
gcp-67	476809.7	6327688	40.814	40.85	0.036
gcp-69	476773.3	6327626	35.784	35.76	-0.024
gcp-71	477596	6326152	52.179	52.2	0.021
gcp-73	477609.8	6326102	48.033	47.99	-0.043
gcp-75	477614.2	6326040	42.007	41.99	-0.017
gcp-77	477590.5	6326006	41.492	41.46	-0.032

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-79	477648.3	6325977	37.94	37.97	0.03
gcp-81	479063	6323738	16.498	16.57	0.072
gcp-83	480627.9	6322920	10.453	10.39	-0.063
gcp-85	480626.5	6322898	9.528	9.52	-0.008
gcp-87	480824.3	6323839	28.724	28.73	0.006
gcp-89	480805.7	6323839	28.701	28.73	0.029
gcp-91	480815.4	6323826	29.065	29.02	-0.045
gcp-93	481891.8	6323208	65.539	65.5	-0.039
gcp-95	482001.1	6323072	60.137	60.16	0.023
gcp-97	482034.1	6323066	61.05	60.93	-0.12
gcp-101	486767.4	6324291	80.421	80.33	-0.091
gcp-103	487793	6324321	142.228	142.28	0.052
gcp-105	487788.1	6324340	142.354	142.29	-0.064
gcp-107	487769.8	6324361	144.967	144.92	-0.047
gcp-109	487787.9	6321603	17.551	17.56	0.009
gcp-111	491001.7	6319067	8.935	8.93	-0.005
gcp-113	490976.8	6319101	6.743	6.73	-0.013
gcp-115	493053	6315957	124.214	124.2	-0.014
gcp-117	493064.1	6315995	123.736	123.64	-0.096
gcp-119	485709.7	6323162	56.125	56.02	-0.105
gcp-121	485603.4	6323105	103.947	103.96	0.013
gcp-123	485442.1	6323071	105.617	105.53	-0.087
gcp-125	485204	6323003	119.852	119.73	-0.122
gcp-127	485081.3	6322897	112.44	112.44	0
gcp-131	484815.5	6322649	59.398	59.38	-0.018
gcp-133	484660	6322461	49.51	49.38	-0.13
gcp-135	484574.9	6322294	39.875	39.72	-0.155
gcp-137	484498.7	6322103	39.256	39.19	-0.066
gcp-139	484506.4	6321839	39.19	39.01	-0.18
gcp-141	486048.3	6322513	6.696	6.71	0.014
gcp-143	486069.7	6322635	6.776	6.72	-0.056
gcp-145	486053.2	6322644	7.058	7.03	-0.028
gcp-147	486076.1	6322619	6.63	6.66	0.03
gcp-149	486045	6322803	7.442	7.4	-0.042
gcp-151	477848.5	6332278	11.967	11.96	-0.007
gcp-153	477807.9	6332249	11.829	11.83	0.001
gcp-155	477764.3	6332527	9.175	9.14	-0.035
gcp-157	479078.5	6331430	18.195	18.21	0.015
gcp-159	479098.3	6331411	17.989	17.98	-0.009
gcp-161	479376.8	6331555	25.316	25.36	0.044

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-163	480093	6330753	71.753	71.8	0.047
gcp-169	480565.5	6331205	51.427	51.36	-0.067
gcp-171	480692.9	6331170	53.62	53.55	-0.07
gcp-173	480807.3	6331133	57.193	57.14	-0.053
gcp-177	481075.3	6331562	263.528	263.65	0.122
gcp-183	477291.9	6331895	5.423	5.35	-0.073
gcp-185	476919.5	6339310	3.636	3.78	0.144
gcp-187	477003.9	6339322	3.871	3.9	0.029
gcp-189	476114.3	6338670	4.096	4.08	-0.016
gcp-195	476119.9	6333387	4.228	4.05	-0.178
gcp-197	477088.3	6335280	4.44	4.37	-0.07
gcp-203	479059.1	6336535	4.317	4.32	0.003
gcp-207	478971.1	6337872	3.847	3.89	0.043
gcp-209	480073.7	6337653	3.763	3.79	0.027
gcp-211	479906.5	6337470	3.919	3.86	-0.059
gcp-213	481832	6337165	3.802	3.92	0.118
gcp-215	481868.1	6337172	3.863	3.75	-0.113
gcp-217	482853.8	6336843	3.802	3.88	0.078
gcp-221	482626.4	6335495	5.17	5.14	-0.03
gcp-223	482665.9	6335500	3.713	3.77	0.057
gcp-227	481355.2	6335655	3.364	3.38	0.016
gcp-231	479789.1	6335529	3.723	3.78	0.057
gcp-233	477291.9	6331895	5.421	5.35	-0.071

Average dz (m)	-0.015
Minimum dz (m)	-0.18
Maximum dz (m)	0.144
Average magnitude (m)	0.048
RMSE (m)	0.063
Standard deviation (m)	0.062

Appendix 2. Checkpoints

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-2	484863	6321108	23.335	23.3	-0.035
gcp-4	484910.3	6321179	20.031	20.04	0.009
gcp-6	484997.7	6321296	13.478	13.56	0.082
gcp-8	485025.2	6321382	11.078	11.1	0.022
gcp-10	485165.8	6321475	9.356	9.35	-0.006
gcp-12	485311.8	6321601	8.784	8.86	0.076
gcp-14	485413.8	6321701	10.224	10.21	-0.014
gcp-16	487759.3	6322427	10.842	10.91	0.068
gcp-18	487755.6	6322448	10.865	10.88	0.015
gcp-20	487774	6322421	11.225	11.27	0.045
gcp-22	485904.4	6322997	15.095	15.15	0.055
gcp-24	485859.6	6322921	14.993	15	0.007
gcp-26	485847.8	6322808	12.784	12.75	-0.034
gcp-28	485870	6322676	9.043	9.07	0.027
gcp-30	485509.6	6321717	11.923	11.85	-0.073
gcp-32	483315.1	6321957	44.156	44.14	-0.016
gcp-34	481878.1	6322696	7.037	7.06	0.023
gcp-36	481524.1	6323292	27.432	27.42	-0.012
gcp-38	481288.5	6323913	23.063	23.02	-0.043
gcp-40	481036.3	6324139	37.361	37.33	-0.031
gcp-42	479818.4	6324459	36.283	36.28	-0.003
gcp-44	479002.1	6324524	29.369	29.4	0.031
gcp-46	478921.3	6324747	28.137	28.12	-0.017
gcp-48	478968.1	6324752	28.815	28.81	-0.005
gcp-50	478027	6325429	45.473	45.56	0.087
gcp-52	476900.3	6326944	9.867	9.84	-0.027
gcp-54	476440.5	6328660	55.191	55.25	0.059
gcp-60	478029.1	6322993	8.561	8.56	-0.001
gcp-62	477529.9	6329109	143.77	143.88	0.11
gcp-64	476814	6327701	41.635	41.68	0.045
gcp-66	476852.3	6327679	41.79	41.74	-0.05
gcp-68	476794.7	6327660	38.543	38.57	0.027
gcp-70	476755.7	6327595	33.153	33.09	-0.063
gcp-72	477603.2	6326129	50.547	50.53	-0.017
gcp-74	477613.4	6326068	44.585	44.52	-0.065
gcp-76	477590.6	6326030	41.729	41.69	-0.039
gcp-78	477615.4	6326003	38.477	38.36	-0.117
gcp-80	477717.4	6325911	40.798	40.83	0.032

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-82	479077	6323743	17.425	17.54	0.115
gcp-84	480615	6322905	9.897	9.87	-0.027
gcp-86	480626.6	6322937	11.208	11.19	-0.018
gcp-88	480817.2	6323849	28.582	28.6	0.018
gcp-90	480815.4	6323826	29.061	29.02	-0.041
gcp-92	481775.4	6323103	37.358	37.33	-0.028
gcp-94	481879	6323190	64.166	64.14	-0.026
gcp-96	482017.4	6323054	61.005	61.04	0.035
gcp-100	485499.2	6321719	12.136	12.21	0.074
gcp-102	487813.1	6324333	142.422	142.46	0.038
gcp-104	487773.8	6324329	142.376	142.36	-0.016
gcp-106	487757.3	6324334	142.519	142.41	-0.109
gcp-108	486475.3	6322680	23.679	23.74	0.061
gcp-110	489427.3	6320005	14.497	14.49	-0.007
gcp-112	490991.5	6319117	8.451	8.46	0.009
gcp-114	491721.6	6316573	36.249	36.25	0.001
gcp-116	493068.6	6315969	123.776	123.61	-0.166
gcp-118	485709.7	6323162	56.115	56.02	-0.095
gcp-120	485622.3	6323261	86.334	86.32	-0.014
gcp-122	485538.7	6323058	104.083	103.88	-0.203
gcp-124	485287.9	6323020	105.698	105.63	-0.068
gcp-126	485151.4	6322951	119.026	119	-0.026
gcp-130	484878	6322752	65.464	65.49	0.026
gcp-134	484607.3	6322360	43.87	43.83	-0.04
gcp-138	484508.9	6321933	37.263	37.27	0.007
gcp-142	486052.7	6322538	6.924	6.92	-0.004
gcp-144	486061.6	6322648	6.855	6.83	-0.025
gcp-146	486052.7	6322621	7.273	7.26	-0.013
gcp-148	486047.2	6322792	7.339	7.31	-0.029
gcp-150	486042.2	6322817	7.475	7.46	-0.015
gcp-152	477829.9	6332265	11.832	11.85	0.018
gcp-154	477754.2	6332515	8.669	8.62	-0.049
gcp-156	478145.6	6332014	9.105	9.17	0.065
gcp-158	479105.9	6331451	18.392	18.31	-0.082
gcp-160	479073.9	6331578	20.587	20.59	0.003
gcp-166	480422	6330203	78.07	78.2	0.13
gcp-168	480548.5	6331188	51.027	51.02	-0.007
gcp-170	480603.8	6331206	52.015	52.04	0.025
gcp-172	480776.1	6331158	56.127	56.26	0.133
gcp-174	481070.8	6331218	89.83	89.87	0.04

Number	Easting (m)	Northing (m)	Known Z (m)	Laser Z (m)	Dz (m)
gcp-176	481082.3	6331557	263.634	263.41	-0.224
gcp-184	476876.9	6339287	3.846	4	0.154
gcp-186	476949.9	6339336	3.428	3.52	0.092
gcp-188	476106.9	6338671	4.059	3.84	-0.219
gcp-190	476077.2	6338610	3.798	3.95	0.152
gcp-200	478073.4	6335814	4.286	4.38	0.094
gcp-204	478834.7	6337836	4.178	4.34	0.162
gcp-206	478936.6	6337839	3.871	4	0.129
gcp-208	480060.5	6337667	3.639	3.81	0.171
gcp-212	479900.2	6337474	4.263	4.1	-0.163
gcp-214	481850.4	6337164	3.869	3.87	0.001
gcp-216	482832.1	6336875	3.64	3.85	0.21
gcp-222	482626.5	6335495	5.18	5.15	-0.03
gcp-224	482666	6335499	3.702	3.82	0.118
gcp-226	481335.8	6335664	3.805	3.93	0.125
gcp-228	481328.4	6335653	4.744	4.82	0.076
gcp-230	479799.8	6335593	3.47	3.5	0.03
gcp-234	477291.9	6331895	5.429	5.35	-0.079

Average dz (m)	0.007
Minimum dz (m)	-0.224
Maximum dz (m)	0.21
Average magnitude (m)	0.059
RMSE (m)	0.08
Standard deviation (m)	0.08