WOOLPERT

USGS FY15 ARS-USDA AZ Walnut Gulch QL1 Lidar

USGS/NGTOC Denver, CO

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Section 1: Overview

Project Name: FY15 ARS-USDA AZ Walnut Gulch QL1 Lidar

Woolpert Project: #75861

This report contains a comprehensive outline of the ARS-USDA AZ Walnut Gulch QL1 Lidar task order. This task is issued under USGS Task Order Number: G15PD00889. This task order requires lidar data to be acquired over Walnut Gulch AZ. The total area of the Walnut Gulch Lidar AOI is approximately 60 square miles situated 60 Miles Southeast of Tucson, AZ. The lidar was collected and processed to meet a maximum Nominal Post Spacing (NPS) of 0.35 meter. The NPS assessment is made against single swath, first return data located within the geometrically usable center portion (typically ~90%) of each swath.

The data was collected using a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) lidar sensor. The ALS70 sensor collects up to four returns per pulse, as well as intensity data, for the first three returns. If a fourth return was captured, the system does not record an associated intensity value. The aerial lidar was collected at the following sensor specifications:

Table 1.1: Acquisition Specs	
Post Spacing	0.8 ft / 0.35m
AGL (Above Ground Level) average flying height	2,950 ft / 899 m
Average Ground Speed:	115 knots / 132 mph
Field of View (full)	32 degrees
Pulse Rate	198.5 kHz
Scan Rate	50 Hz
Side Lap	25%

The lidar data was processed and projected in UTM, WGS84, Zone 12 in units of meters. The vertical datum used for the task order was referenced EGM 2008, in units of meters.

Figure 1.1: Lidar Task Order AOI

Section 2: Acquisition

The existing lidar data was acquired with a Leica ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar Sensor System, on board Precision Aerial Reconnaissance (PAR) Cessna aircraft. The ALS70 lidar system, developed by Leica Geosystems of Heerbrugg, Switzerland, includes the simultaneous first, intermediate and last pulse data capture module, the extended altitude range module, and the target signal intensity capture module. The system software is operated on an OC50 Operation Controller aboard the aircraft.

The ALS70 500 kHz Multiple Pulses in Air (MPiA) Lidar System has the following specifications:

Table 2.1: ALS Lidar System Specifications	
Operating Altitude	200 – 3,500 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 200 Hz (variable based on scan angle)
Maximum Pulse Rate	500 kHz (Effective)
Range Resolution	Better than 1 cm
Elevation Accuracy	7 - 16 cm single shot (one standard deviation)
Horizontal Accuracy	5 – 38 cm (one standard deviation)
Number of Returns per Pulse	7 (infinite)
Number of Intensities	3 (first, second, third)
Intensity Digitization	8 bit intensity + 8 bit AGC (Automatic Gain Control) level
MPiA (Multiple Pulses in Air)	8 bits @ 1nsec interval @ 50kHz
Laser Beam Divergence	0.22 mrad @ $1/e^2$ (~0.15 mrad @ 1/e)
Laser Classification	Class IV laser product (FDA CFR 21)
Eye Safe Range	400m single shot depending on laser repetition rate
Roll Stabilization	Automatic adaptive, range = 75 degrees minus current FOV
Power Requirements	28 VDC @ 25A
Operating Temperature	0-40°C
Humidity	0-95% non-condensing
Supported GNSS Receivers	Ashtech Z12, Trimble 7400, Novatel Millenium

Prior to mobilizing to the project site, PAR flight crews coordinated with the necessary Air Traffic Control personnel to ensure airspace access.

Woolpert survey crews were onsite, operating a Global Navigation Satellite System (GNSS) Base Station for the airborne GPS support.

The lidar data was collected in three (3) separate missions, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area.

An initial quality control process was performed immediately on the lidar data to review the data coverage, airborne GPS data, and trajectory solution. Any gaps found in the lidar data were relayed to the flight crew, and the area was re-flown.

Figure 2.1: FY15 ARS-USDA AZ Walnut Gulch QL1 Lidar

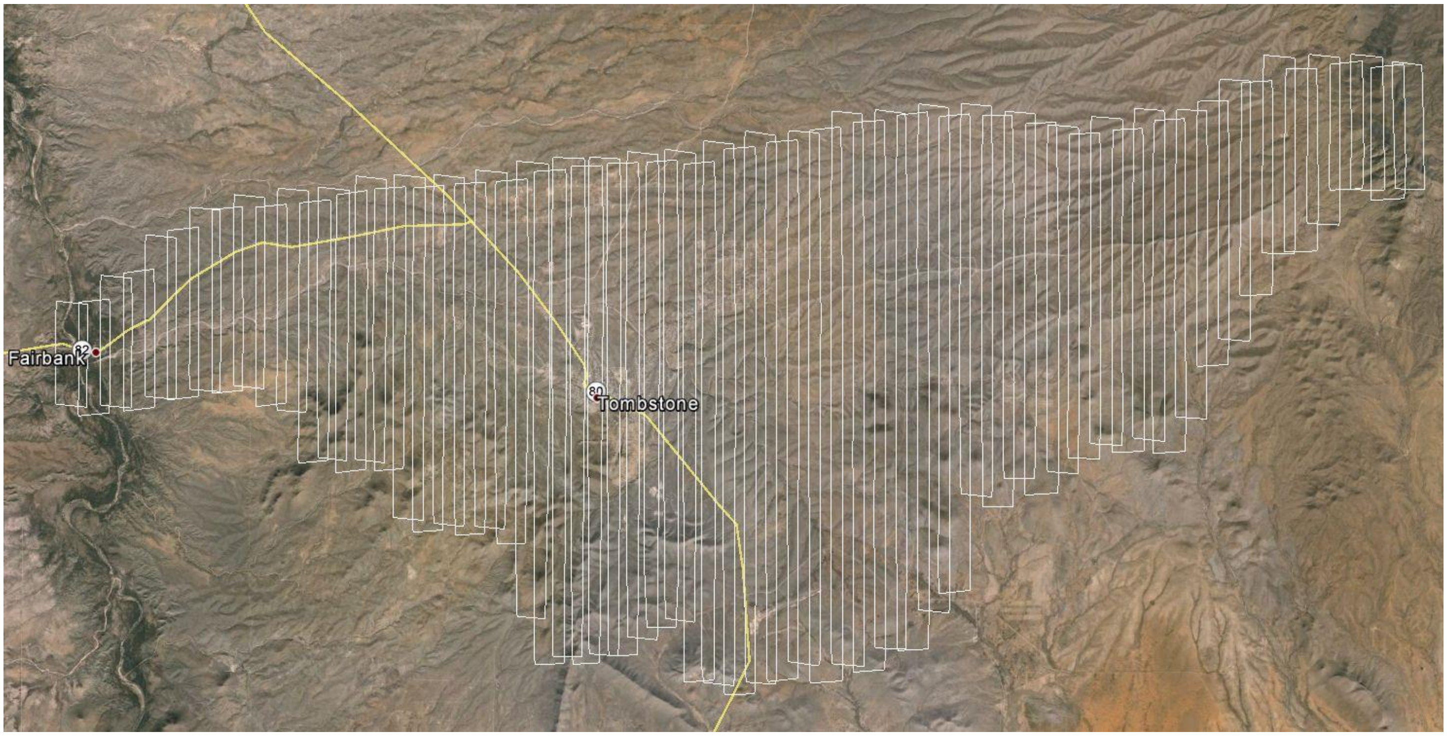


Table 2.2: Airborne Lidar Acquisition Flight Summary			
Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down	Mission Time (Local = EDT) Wheels Up/ Wheels Down
September 16, 2015_A	1-30, 67	15:13 – 18:57	08:13 AM – 11:57 AM
September 16, 2015_B	31-67	19:43 – 00:26	12:43 PM - 05:26 PM
September 18, 2015	1-2, 15-16, 63-64	14:25 – 15:34	07:25 AM – 08:34 AM

Section 3: Lidar Data Processing

Applications and Work Flow Overview

1. Resolved kinematic corrections for three subsystems: inertial measurement unit (IMU), sensor orientation information and airborne GPS data. Developed a blending post-processed aircraft position with attitude data using Kalman filtering technology or the smoothed best estimate trajectory (SBET).
   Software: POSPac Software v. 5.3, IPAS Pro v.1.35.
2. Calculated laser point position by associating the SBET position to each laser point return time, scan angle, intensity, etc. Created raw laser point cloud data for the entire survey in LAS format. Automated line-to-line calibrations were then performed for system attitude parameters (pitch, roll, heading), mirror flex (scale) and GPS/IMU drift.
   Software: Leica Cloud Pro v 1.2.1, Proprietary Software, TerraMatch v. 15.015.
3. Imported processed LAS point cloud data into the task order tiles. Resulting data were classified as ground and non-ground points with additional filters created to meet the task order classification specifications. Statistical absolute accuracy was assessed via direct comparisons of ground classified points to ground RTK survey data. Based on the statistical analysis, the lidar data was then adjusted to reduce the vertical bias when compared to the survey ground control.
   Software: TerraScan v.15.026.
4. The LAS files were evaluated through a series of manual QA/QC steps to eliminate remaining artifacts from the ground class.
   Software: TerraScan v.15.026.

Global Navigation Satellite System (GNSS) – Inertial Measurement Unit (IMU) Trajectory Processing

Equipment

Flight navigation during the lidar data acquisition mission is performed using IGI CCNS (Computer Controlled Navigation System). The pilots are skilled at maintaining their planned trajectory, while holding the aircraft steady and level. If atmospheric conditions are such that the trajectory, ground speed, roll, pitch and/or heading cannot be properly maintained, the mission is aborted until suitable conditions occur.

The aircraft are all configured with a NovAtel Millennium 12-channel, L1/L2 dual frequency Global Navigation Satellite System (GNSS) receivers collecting at 2 Hz.

All Woolpert aerial sensors are equipped with a Litton LN200 series Inertial Measurement Unit (IMU) operating at 200 Hz.

A base-station unit was mobilized for each acquisition mission and was operated by a member of the acquisition team. Ground planes were used on the base-station antennas. Data was collected at 1 or 2 Hz.

The GNSS base station operated during the Lidar acquisition missions is listed below:

Table 3.1: GNSS Base Station

Station (Name)	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase center) (Meters)
TombstoneBase	31° 40' 04.19862"	-110° 01' 43.92418"	1417.825

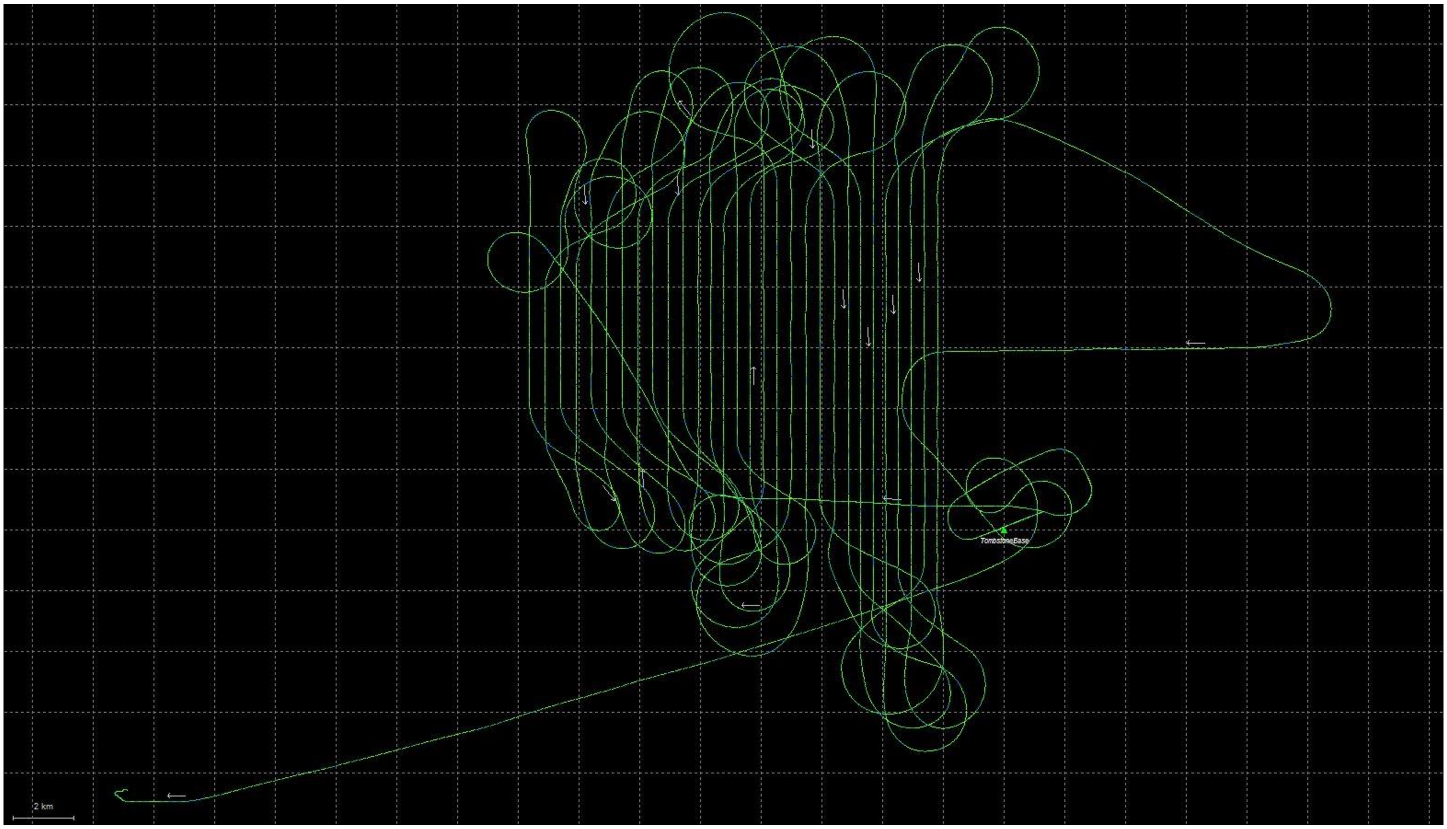
Data Processing

All airborne GNSS and IMU data was post-processed and quality controlled using Applanix MMS software. GNSS data was processed at a 1 and 2 Hz data capture rate and the IMU data was processed at 200 Hz.

Trajectory Quality

The GNSS Trajectory, along with high quality IMU data are key factors in determining the overall positional accuracy of the final sensor data. Within the trajectory processing, there are many factors that affect the overall quality, but the most indicative are the Combined Separation, the Estimated Positional Accuracy, and the Positional Dilution of Precision (PDOP).

Figure 3.1: Trajectory, Day25915_PAR_A

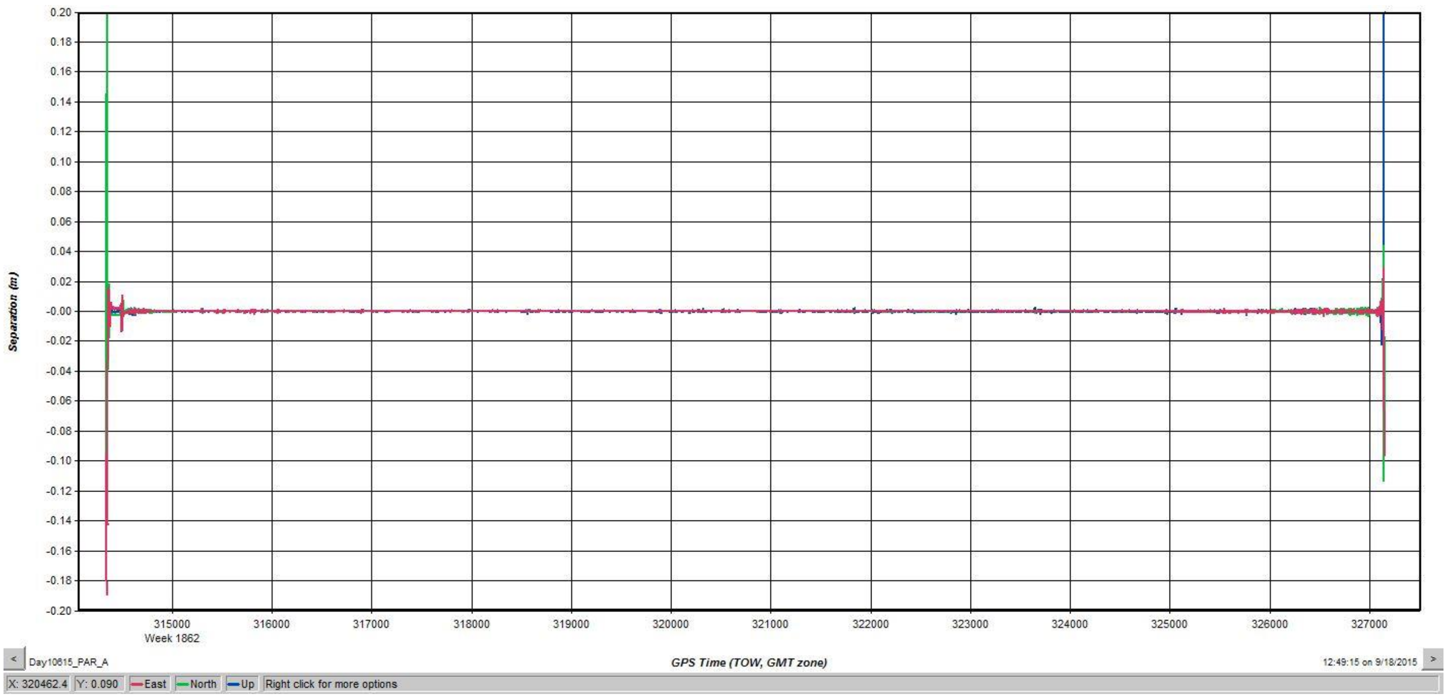


Combined Separation

The Combined Separation is a measure of the difference between the forward run and the backward run solution of the trajectory. The Kalman filter is processed in both directions to remove the combined directional anomalies. In general, when these two solutions match closely, an optimally accurate reliable solution is achieved.

Woolpert's goal is to maintain a Combined Separation Difference of less than ten (10) centimeters. In most cases we results below this threshold are achieved.

Figure 3.2: Combined Separation, Day25915_PAR_A

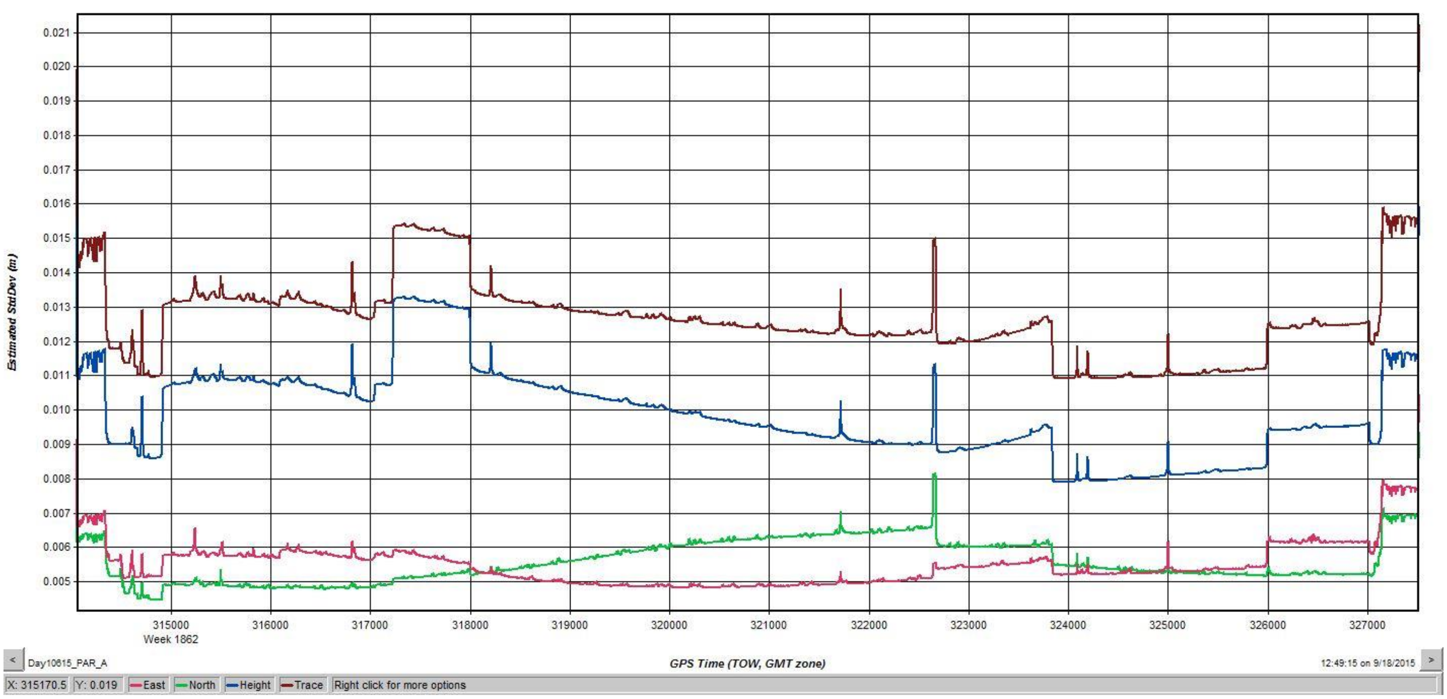


Estimated Positional Accuracy

The Estimated Positional Accuracy plots the standard deviations of the east, north, and vertical directions along a time scale of the trajectory. It illustrates loss of satellite lock issues, as well as issues arising from long baselines, noise, and/or other atmospheric interference.

Woolpert's goal is to maintain an Estimated Positional Accuracy of less than ten (10) centimeters, often achieving results well below this threshold.

Figure 3.3: Estimated Positional Accuracy, Day25915_PAR_A

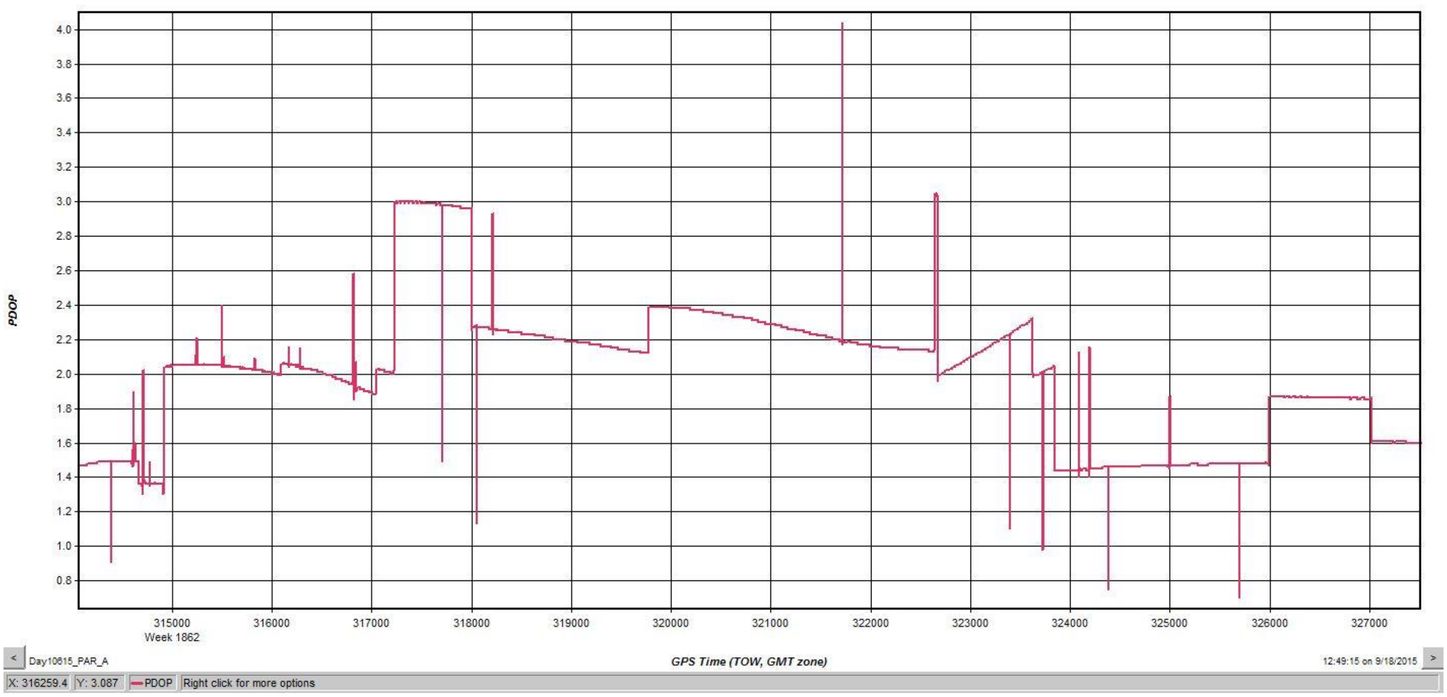


PDOP

The PDOP measures the precision of the GPS solution in regards to the geometry of the satellites acquired and used for the solution.

Woolpert's goal is to maintain an average PDOP value below 3.0. Brief periods of PDOP over 3.0 are acceptable due to the calibration and control process if other metrics are within specification.

Figure 3.4: PDOP, Day25915_PAR_A



Lidar Data Processing

When the sensor calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert lidar specialists included:

- Processed individual flight lines to derive a raw “Point Cloud” LAS file. Matched overlapping flight lines, generated statistics for evaluation comparisons, and made the necessary adjustments to remove any residual systematic error.
- Calibrated LAS files were imported into the task order tiles and initially filtered to create a ground and non-ground class. Then additional classes were filtered as necessary to meet client specified classes.
- Once all project data was imported and classified, survey ground control data was imported and calculated for an accuracy assessment. As a QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparisons against the TIN and the DEM using surveyed ground control of higher accuracy. The lidar is adjusted accordingly to meet or exceed the vertical accuracy requirements.
- The lidar tiles were reviewed using a series of proprietary QA/QC procedures to ensure it fulfills the task order requirements. A portion of this requires a manual step to ensure anomalies have been removed from the ground class.
- The lidar LAS files are classified into the Default (Class 1), Ground (Class 2), Low Noise(Class 7), Bridge Decks (Class 17), and High Noise (Class 18) classifications.
- FGDC Compliant metadata was developed for the task order in .xml format for the final data products.
- The horizontal datum used for the task order was referenced to UTM12N, WGS84. The vertical datum used for the task order was referenced to EGM 2008, meters. Coordinate positions were specified in units of meters.
- Relative accuracy also known as "between swath" accuracy was tested through a series of well distributed flight line overlap locations. The relative accuracy for the Portsmouth DOE Lidar tested at 0.040 meters RMSDz.

Section 4: ACCURACY ASSESSMENT

Accuracy Assessment

The vertical accuracy statistics were calculated by comparison of the lidar bare earth points to the ground surveyed QA/QC points.

Table 4.1: Overall Vertical Accuracy Statistics,		
Average error	0.024	Meter
Minimum error	-0.074	Meter
Maximum error	+0.105	Meter
Average magnitude	0.046	Meter
Root mean square	0.053	Meter
Standard deviation	0.048	Meter

Table 4.2: Raw Swath Quality Check Point Analysis NVA

Point ID	Easting (UTM Meter)	Northing (UTM Meter)	TIN Elevation (Meter)	Dz (Meter)
2001	577135.542	3509910.189	1180.93	-0.035
2002	580195.478	3510784.987	1230.11	0.081
2003	582506.358	3512553.344	1273.55	0.071
2004	585530.421	3512880.091	1307.23	0.105
2005	586759.241	3511584.357	1328.66	0.048
2006	584933.939	3510907.588	1313.75	0.032
2007	585527.754	3507110.881	1377.3	0.058
2008	588840.03	3508862.143	1392.93	0.061
2009	591097.203	3506681.606	1432.69	-0.036
2010	591854.165	3503955.193	1450.17	-0.061
2011	595036.832	3504720.016	1444.64	-0.074
2012	595176.191	3509236.424	1419.13	0.017
2013	597907.656	3509489.035	1439.93	0.046
2014	591349.763	3510364.949	1384.33	0.038
2015	593008.831	3512584.269	1414.59	0.057
2016	594923.759	3513883.36	1444.06	0.024
2017	596471.492	3511920.937	1473.69	0.015
2018	600795.52	3512553.005	1551.55	0.011
2019	602637.011	3512973.166	1596.66	-0.004
2020	603921.559	3515010.82	1618.63	0.007
2021	589044.055	3513330.87	1355.18	0.07
2022	593220.268	3508131.308	1415.87	-0.04
2023	582353.737	3510059.467	1285.08	0.072

2024	599456.015	3510645.262	1486.33	-0.025
2025	587691.543	3505743.605	1496.19	0.069

VERTICAL ACCURACY CONCLUSIONS

Raw LAS Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.103 meters at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using all points.

LAS Swath Non-Vegetated Vertical Accuracy (NVA) Tested 0.088 meters at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the TIN using ground points.

NVA/VVA ASSESMENT

Table 4.3: Non-Vegetated Vertical Accuracy Quality Check Point Analysis NVA

Point ID	Easting (UTM Meter)	Northing (UTM Meter)	DEM Elevation (Meter)	Dz (Meter)
2001	577135.542	3509910.189	1180.93	0.035
2002	580195.478	3510784.987	1230.03	-0.001
2003	582506.358	3512553.344	1273.53	-0.051
2004	585530.421	3512880.091	1307.13	-0.005
2005	586759.241	3511584.357	1328.65	-0.038
2006	584933.939	3510907.588	1313.71	0.008
2007	585527.754	3507110.881	1377.26	-0.018
2008	588840.03	3508862.143	1392.93	-0.061
2009	591097.203	3506681.606	1432.65	0.076
2010	591854.165	3503955.193	1450.14	0.091
2011	595036.832	3504720.016	1444.62	0.094
2012	595176.191	3509236.424	1419.1	0.013
2013	597907.656	3509489.035	1439.92	-0.036
2014	591349.763	3510364.949	1384.27	0.022
2015	593008.831	3512584.269	1414.57	-0.037
2016	594923.759	3513883.36	1444.05	-0.014
2017	596471.492	3511920.937	1473.62	0.055
2018	600795.52	3512553.005	1551.58	-0.041
2019	602637.011	3512973.166	1596.66	0.004
2020	603921.559	3515010.82	1618.65	-0.027
2021	589044.055	3513330.87	1355.13	-0.02
2022	593220.268	3508131.308	1415.89	0.02
2023	582353.737	3510059.467	1285.02	-0.012
2024	599456.015	3510645.262	1486.29	0.065
2025	587691.543	3505743.605	1496.17	-0.049

VERTICAL ACCURACY CONCLUSIONS

Bare-Earth DEM Non-Vegetated Vertical Accuracy (NVA) Tested 0.086 meters at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

Table 4.4: Vegetated Vertical Accuracy Quality Check Point Analysis VVA

Point ID	Easting (UTM Meter)	Northing (UTM Meter)	DEM Elevation (Meter)	Dz (Meter)
3001	603788.634	3514947.548	1608.6	-0.248
3002	576998.991	3509847.723	1177.83	-0.057
3003	595066.014	3504752.957	1443.4	0.017
3004	596774.59	3511934.126	1471.51	-0.018
3005	589149.955	3509018.327	1380.44	-0.093
3006	582466.319	3512567.186	1273.8	-0.07
3007	585378.488	3507305.38	1368.42	-0.006
3008	589060.323	3513307.316	1354.67	-0.105

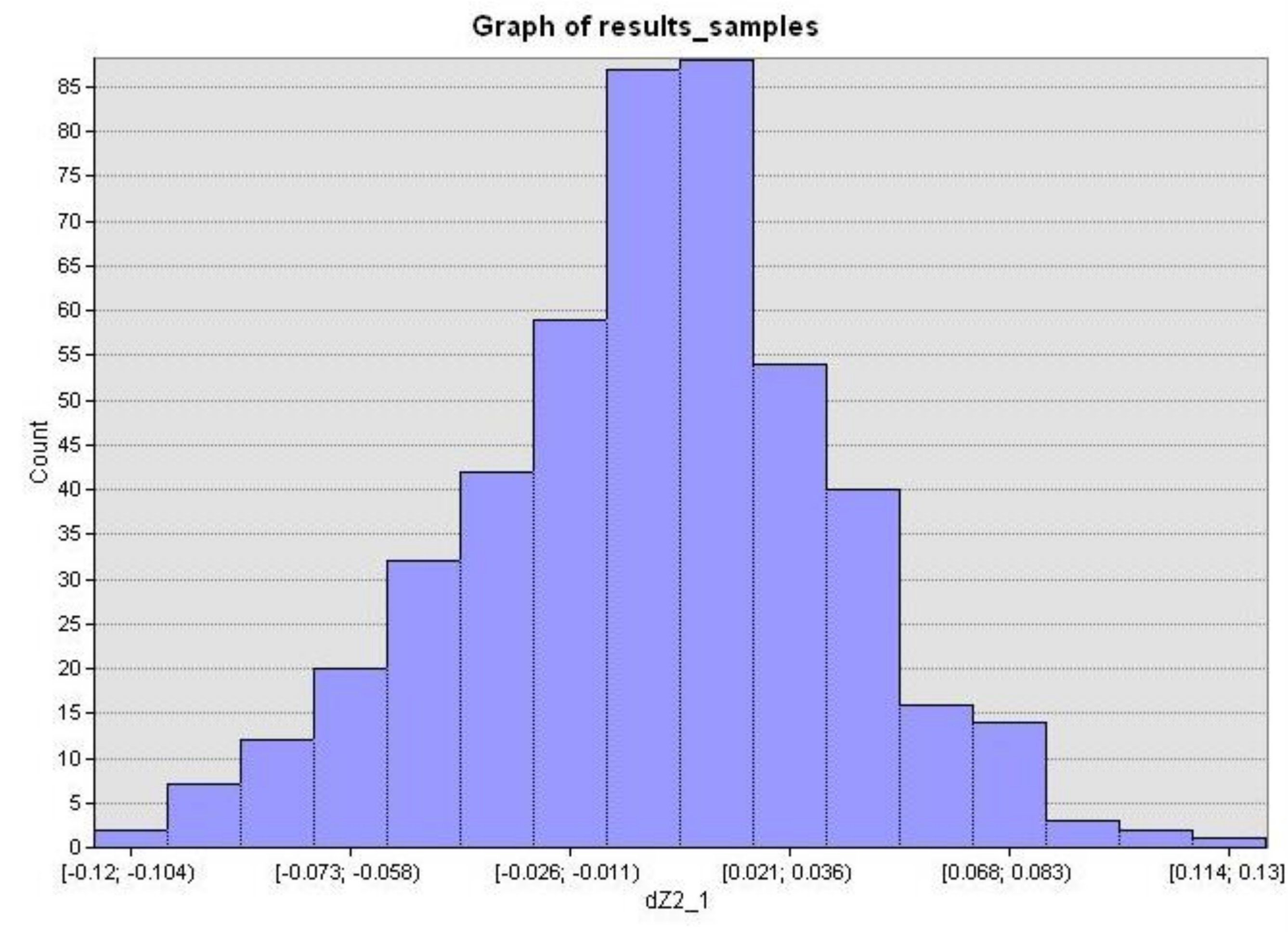
VERTICAL ACCURACY CONCLUSIONS

Vegetated Vertical Accuracy (VVA) Tested 0.197 meters at the 95th percentile reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM. VVA Errors larger than 95th percentile include:
Point 3001, Easting 603788.634, Northing 3514947.548, Z-Error 0.248 meters

Relative Accuracy

Relative accuracy also known as "between swath" accuracy was tested through a series of well distributed flight line overlap locations. The relative accuracy for the Portsmouth DOE Lidar tested at 0.040 meters RMSDz.

Figure 4.1: FY15 ARS-USDA AZ Walnut Gulch QL1 Lidar



Approved by:	Name	Signature	Date
Associate Member, Lidar Specialist Certified Photogrammetrist #1381	Qian Xiao	[signature]	February 2016

Section 5: Flight Logs

Flight logs for the project are shown on the following pages:

LIDAR Daily Log

Field Crew	RCD S, DRIVE 012	
Project #	TBA	
Project Description	Woolpert Walnut Gulch	
Location	Tombstone, AZ	
Mission	MISSION 1	
Sensor	ALS70	
Aircraft	N799AC	
SENSOR NAVIGATION FILE NAME	20150916_150932	
Lever Arm GPS (m)	x -0.110, y 0.210, z -1.220	
GPS Information	Base 1: 19822590.T02; Base 2; Base3; Aero 1	
AGC	Auto	
IMU Information	Start Time 15:13:21	Stop Time 18:57:40

Meteorological Conditions	Elevation	Temp			Pressure
Airport	4,743	23.0°c	296.15°k	29.94 inHg	101388 Pa
@ Altitude	2950AGL	27.0°c	300.15°k	29.92 inHg	101321 Pa
@ Altitude					

GPS Base Station Information	File Name	RNX File	Ant Hgt	Ant Type
Base 1	19822590.T02		2.05m	Trimble R10
Base 2				
Base 3				

Total Time	FOV	Scan Rate	Pulse Rate Hz	Roll Comp	Muti Pulse (Y,N)	Altitude ellipsoid (m)	Altitude ellipsoid (ft)	Speed	Nautical Miles Flown	Void "Y"	PDOP	Operator	Conditions/Comments
0:00:40	30.5	50.0	198500	YES	N	1316	4318					Parker	GOOD
0:00:41	30.6	50.0	198500	YES	N	1293	4242					Parker	GOOD
0:00:46	30.5	50.0	198500	YES	N	1302	4272					Parker	GOOD
0:00:46	30.5	50.0	198500	YES	N	1298	4259					Parker	GOOD
0:00:58	30.5	50.0	198500	YES	N	1294	4245					Parker	GOOD
0:01:04	30.6	50.0	198500	YES	N	1285	4216					Parker	GOOD
0:01:09	30.5	50.0	198500	YES	N	1272	4173					Parker	GOOD
0:01:03	30.5	50.0	198500	YES	N	1287	4222					Parker	GOOD
0:01:09	30.5	50.0	198500	YES	N	1274	4180					Parker	GOOD
0:01:09	30.5	50.0	198500	YES	N	1279	4196					Parker	GOOD
0:01:21	30.6	50.0	198500	YES	N	1290	4232					Parker	GOOD
0:01:31	30.6	50.0	198500	YES	N	1194	3917					Parker	GOOD
0:01:37	30.6	50.0	198500	YES	N	1295	4249					Parker	GOOD
0:01:37	30.6	50.0	198500	YES	N	1247	4091					Parker	GOOD
0:01:44	30.6	50.0	198500	YES	N	1278	4193					Parker	GOOD
0:01:44	30.6	50.0	198500	YES	N	1221	4006					Parker	GOOD
0:02:06	30.5	50.0	198500	YES	N	1286	4219					Parker	GOOD
0:02:01	30.5	50.0	198500	YES	N	1234	4049					Parker	GOOD
0:02:12	30.6	50.0	198500	YES	N	1276	4186					Parker	GOOD
0:02:07	30.5	50.0	198500	YES	N	1231	4039					Parker	GOOD
0:02:12	30.6	50.0	198500	YES	N	1293	4242					Parker	GOOD
0:02:12	30.6	50.0	198500	YES	N	1180	3871					Parker	GOOD
0:02:47	30.5	50.0	198500	YES	N	1317	4321					Parker	GOOD
0:02:58	30.6	50.0	198500	YES	N	1222	4009					Parker	GOOD
0:03:04	30.6	50.0	198500	YES	N	1291	4236					Parker	GOOD
0:03:04	30.6	50.0	198500	YES	N	1190	3904					Parker	GOOD
0:03:10	30.5	50.0	198500	YES	N	1261	4137					Parker	GOOD
0:02:58	30.6	50.0	198500	YES	N	1192	3911					Parker	GOOD
0:03:04	30.6	50.0	198500	YES	N	1249	4098					Parker	GOOD
0:02:46	30.6	50.0	198500	YES	N	1183	3881					Parker	GOOD
0:25:18	30.6	50.0	197600	YES	N	1219	3999					Parker	DO NOT USE

PAR LLC
PRECISION AERIAL RECONNAISSANCE
P.O. Box 72357
Bossier City, LA 72357

LIDAR Daily Log

Field Crew		
Project #	TBA	
Project Description	Woolpert Walnut Gulch	
RCD B	DRIVE 014	
Location	Tombstone, AZ	
MISSION 2		

Flight Date (UTC)	Pilot	Operator	Sensor	Aircraft	SENSOR NAVIGATION FILE NAME
9/16/2015	Farrar	Parker	ALS70	N799AC	20150916_194021

Lever Arm	x	y	z
GPS (m)	-0.110	0.210	-1.220

GPS Information	
Base 1	19822590.T02
Base 2	
Base3	
Aero 1	
IMU Information	
Start Time	19:43:09
Stop Time	0:25:50

AGC	
Auto	

Meteorological Conditions	Elevation	Temp			Pressure
Airport	4,743	23.0'c	296.15'k	29.94 inHg	101388 Pa
@ Altitude	2950AGL	27.0'c	300.15'k	29.92 inHg	101321 Pa
@ Altitude					

GPS Base Station Information	File Name	RNX File	Ant Hgt	Ant Type
Base 1	19822590.T02		2.05m	Trimble R10
Base 2				
Base 3				

Reflight	Line	Dir	Start	Stop	Total Time	FOV	Scan Rate	Pulse Rate Hz	Roll Comp	Muti Pulse (Y,N)	Altitude ellipsoid (m)	Altitude ellipsoid (ft)	Speed	Nautical Miles Flown	Void "Y"	PDOP	Operator	Conditions/Comments
	66	LDR150916_201627_	20:16:43	20:19:59	0:03:16	30.6	50.0	198500	YES	N	1294	4245					Parker	GOOD
	65	LDR150916_202741_	20:27:58	20:28:50	0:00:52	30.6	50.0	198500	YES	N	1299	4262					Parker	GOOD
	64	LDR150916_203204_	20:32:21	20:33:07	0:00:46	30.6	50.0	198500	YES	N	1285	4216					Parker	GOOD
	63	LDR150916_203710_	20:37:27	20:38:18	0:00:51	30.5	50.0	198500	YES	N	1290	4232					Parker	GOOD
	62	LDR150916_204124_	20:41:40	20:42:21	0:00:41	30.6	50.0	198500	YES	N	1312	4304					Parker	GOOD
	61	LDR150916_204550_	20:46:07	20:47:10	0:01:03	30.5	50.0	198500	YES	N	1227	4026					Parker	GOOD
	60	LDR150916_205027_	20:50:44	20:51:47	0:01:03	30.6	50.0	198500	YES	N	1324	4344					Parker	GOOD
	59	LDR150916_205542_	20:55:59	20:57:08	0:01:09	30.6	50.0	198500	YES	N	1268	4160					Parker	GOOD
	58	LDR150916_210027_	21:00:43	21:01:58	0:01:15	30.5	50.0	198500	YES	N	1301	4268					Parker	GOOD
	57	LDR150916_210525_	21:05:41	21:07:19	0:01:38	30.5	50.0	198500	YES	N	1235	4052					Parker	GOOD
	56	LDR150916_211053_	21:11:08	21:12:46	0:01:38	30.6	50.1	198500	YES	N	1293	4242					Parker	GOOD
	55	LDR150916_211609_	21:16:26	21:18:15	0:01:49	30.5	50.0	198500	YES	N	1248	4094					Parker	GOOD
	54	LDR150916_212133_	21:21:49	21:23:44	0:01:55	30.5	50.0	198500	YES	N	1300	4265					Parker	GOOD
	53	LDR150916_212703_	21:27:19	21:29:20	0:02:01	30.5	50.0	198500	YES	N	1210	3970					Parker	GOOD
	52	LDR150916_213248_	21:33:05	21:35:00	0:01:55	30.5	50.0	198500	YES	N	1295	4249					Parker	GOOD
	51	LDR150916_213836_	21:38:52	21:40:53	0:02:01	30.5	50.0	198500	YES	N	1241	4072					Parker	GOOD
	50	LDR150916_214411_	21:44:27	21:46:28	0:02:01	30.5	50.0	198500	YES	N	1279	4196					Parker	GOOD
	49	LDR150916_214936_	21:49:53	21:51:59	0:02:06	30.5	50.0	198500	YES	N	1219	3999					Parker	GOOD
	48	LDR150916_215517_	21:55:34	21:57:40	0:02:06	30.5	50.0	198500	YES	N	1332	4370					Parker	GOOD
	47	LDR150916_220128_	22:01:44	22:04:01	0:02:17	30.5	50.0	198500	YES	N	1232	4042					Parker	GOOD
	46	LDR150916_220735_	22:07:51	22:10:15	0:02:24	30.6	50.0	198500	YES	N	1246	4088					Parker	GOOD
	45	LDR150916_221359_	22:14:16	22:16:40	0:02:24	30.6	50.0	198500	YES	N	1224	4016					Parker	GOOD
	44	LDR150916_222031_	22:20:47	22:23:39	0:02:52	30.5	50.0	198500	YES	N	1292	4239					Parker	GOOD
	43	LDR150916_222650_	22:27:06	22:30:15	0:03:09	30.6	50.0	198500	YES	N	1210	3970					Parker	GOOD
	42	LDR150916_223304_	22:33:20	22:36:36	0:03:16	30.5	50.0	198500	YES	N	1263	4144					Parker	GOOD
	41	LDR150916_224015_	22:40:31	22:43:58	0:03:27	30.6	50.0	198500	YES	N	1234	4049					Parker	GOOD
	40	LDR150916_224700_	22:47:16	22:50:37	0:03:21	30.6	50.1	198500	YES	N	1285	4216					Parker	GOOD
	39	LDR150916_225339_	22:53:55	22:57:22	0:03:27	30.5	50.0	198500	YES	N	1242	4075					Parker	GOOD
	38	LDR150916_230040_	23:00:56	23:04:17	0:03:21	30.6	50.0	198500	YES	N	1315	4314					Parker	GOOD
	37	LDR150916_230740_	23:07:56	23:11:23	0:03:27	30.5	50.0	198500	YES	N	1236	4055					Parker	GOOD
	36	LDR150916_231420_	23:14:36	23:17:46	0:03:10	30.6	50.0	198500	YES	N	1242	4075					Parker	GOOD
	35	LDR150916_232059_	23:21:15	23:24:41	0:03:26	30.5	50.0	198500	YES	N	1253	4111					Parker	GOOD
	34	LDR150916_232734_	23:27:50	23:31:11	0:03:21	30.5	50.0	198500	YES	N	1218	3996					Parker	GOOD
	33	LDR150916_233441_	23:34:57	23:38:24	0:03:27	30.6	50.0	198500	YES	N	1222	4009					Parker	GOOD
	32	LDR150916_234115_	23:41:31	23:44:35	0:03:04	30.5	50.0	198500	YES	N	1206	3957					Parker	GOOD
	31	LDR150916_234800_	23:48:16	23:51:14	0:02:58	30.6	50.0	198500	YES	N	1250	4101					Parker	GOOD
	67	LDR150916_235623_	23:56:39	0:03:04	0:06:25	30.6	50.0	198500	YES	N	1038	3406					Parker	GOOD

LIDAR FLIGHT SUMMARY

		Hobbs Start	2527.6
Aircraft IMU Time	4:42:41	Hobbs Stop	2532.2
Sensor Collection Time	1:29:22	Hobbs Total	4.6
Line Miles Flown	0.0	Mission Hobbs	#DIV/0!
Average Flight Lines Speed	0 kts	Reflight Hobbs	#DIV/0!
Average Nautical Line miles Per Mission Hour			#DIV/0!

DATA COLLECTION

Total Lines	0	Project % Complete	#DIV/0!
# Reflight Lines	0	Total Flight Lines	0
Reflight Percent	#DIV/0!	Line Complete	0
Sensor Re-Flight Miles	0.0	Mission Lines	0
Average Nautical Line Miles Per Re-Flight Hour	#DIV/0!		

Comments

Cloud Cover

Clear	X
Fair	
Partly Cloudy	
Cloudy	

PAR LLC
PRECISION AERIAL RECONNAISSANCE
P.O. Box 72357
Bossier City, LA 72357

LIDAR Daily Log

Field Crew	RCD B	DRIVE 011	MISSION 3
Project #	TBA		
Project Description	Woolpert Walnut Gulch		
Location	Tombstone, AZ		
Flight Date (UTC)	9/18/2015		
Pilot	Farrar		
Operator	Parker		
Sensor	ALS70		
Aircraft	N799AC		
SENSOR NAVIGATION FILE NAME	20150918_142229		

Lever Arm	x	y	z
GPS (m)	-0.110	0.210	-1.220

GPS Information		AGC
Base 1	19822610.T02	Auto
Base 2		
Base3		
Aero 1		

IMU Information	
Start Time	14:25:10
Stop Time	15:34:05

Meteorological Conditions	Elevation	Temp			Pressure
Airport	4,743	23.0 c	296.15 k	29.94 inHg	101388 Pa
@ Altitude	2950AGL	27.0 c	300.15 k	29.92 inHg	101321 Pa
@ Altitude					

GPS Base Station Information	File Name	RNX File	Ant Hgt	Ant Type
Base 1	19822610.T02		2.05m	Trimble R10
Base 2				
Base 3				

Reflight	Line	Dir	Start	Stop	Total Time	FOV	Scan Rate	Pulse Rate Hz	Roll Comp	Muti Pulse (Y,N)	Altitude ellipsoid (m)	Altitude ellipsoid (ft)	Speed	Nautical Miles Flown	Void "Y"	PDOP	Operator	Conditions/Comments
	16	LDR150918_144300_	14:43:19	14:45:02	0:01:43	30.5	50.0	198500	YES	N	1222	4009					Parker	GOOD
	15	LDR150918_144833_	14:48:51	14:50:34	0:01:43	30.5	50.0	198500	YES	N	1294	4245					Parker	GOOD
	UL001	LDR150918_145411_	14:54:30	14:55:04	0:00:34	30.5	50.0	198500	YES	N	1247	4091					Parker	GOOD
	64	LDR150918_150458_	15:05:17	15:06:08	0:00:51	30.6	50.0	198500	YES	N	1300	4265					Parker	GOOD
	63	LDR150918_150947_	15:10:05	15:10:51	0:00:46	30.5	50.0	198500	YES	N	1299	4262					Parker	GOOD
	UL002	LDR150918_151642_	15:17:01	15:20:05	0:03:04	30.5	50.0	198500	YES	N	1344	4409					Parker	GOOD

Section 6: Final Deliverables

The final lidar deliverables are listed below.

- LAS v1.4 classified point cloud
- LAS v1.4 raw unclassified point cloud flight line
- Bare Earth Surface Raster DEM
- First Return DSM IMG Format
- 8-bit gray scale intensity Tiff images
- Tile layout USNG and data extent provided as ESRI shapefile
- FGDC compliant metadata per product in XML format
- Lidar processing report in pdf format
- Survey report in .pdf format