AIRBORNE LIDAR PROJECT REPORT

NRCS AR-TN LIDAR TASK ORDER

UNITED STATES GEOLOGICAL SURVEY (USGS)

CONTRACT NUMBER: G10PC00057
TASK ORDER NUMBER: G10PD01063

WOOLPERT PROJECT #70452

SEPTEMBER 2010

PREPARED BY:
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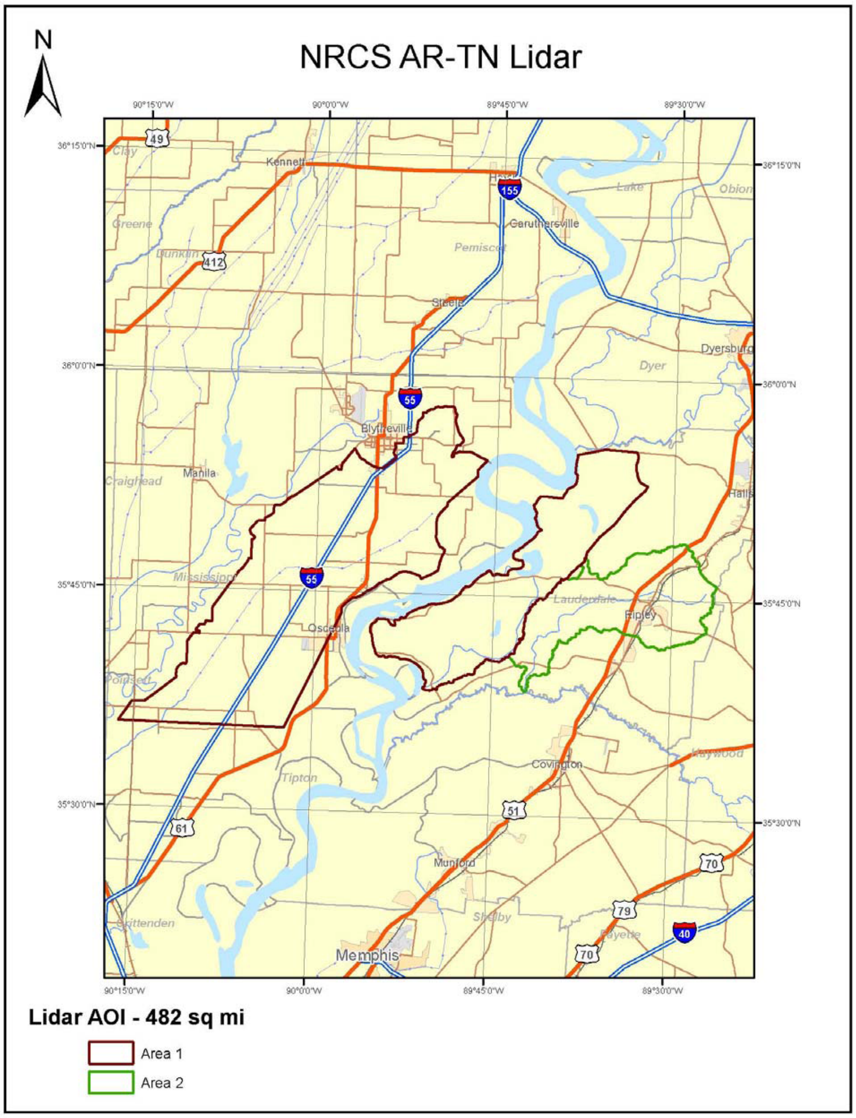
SECTION 1: OVERVIEW

Task Order Name: NRCS AR-TN LIDAR

Woolpert Project #70452

This report contains a comprehensive outline of the airborne LiDAR data acquisition for the NRCS AR-TN LiDAR Task Order; Contract Number G10PC00057; Task Order Number G10PD01063, for the United States Geological Survey (USGS). The task order consisted of LiDAR data acquisition, processing, hydrologic flattening of water bodies and production of derivative products of approximately 482 square miles in Arkansas and Tennessee. The LiDAR data was collected at a nominal pulse spacing (NPS) of 0.70 meters for Area 1 (395 sq. mi.) and at a nominal pulse spacing of 0.50 meters for Area 2 (87 sq. mi.).

Figure 1.1: NRCS AR-TN LiDAR Task Order Area of Interest



The data was collected using a Leica ALS50-II 150 kHz Multiple Pulses in Air (MPiA) LiDAR sensor installed in a Leica gyro-stabilized PAV30 mount. The ALS50-II 150 kHz 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.

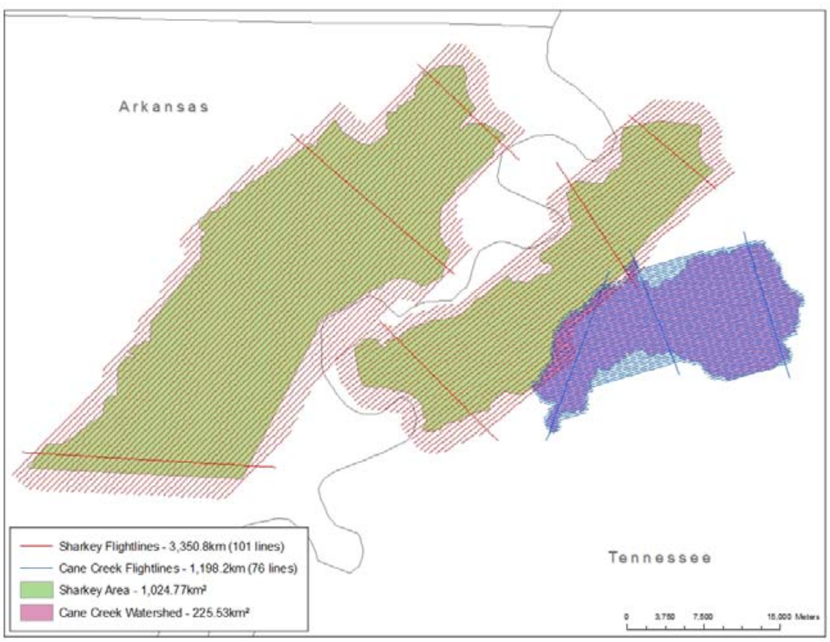
The LiDAR data for the Area 1 (Sharkey) AOI was acquired at the following specifications:

Flying Height .... 2,000 Meters AGL
Aircraft Speed .... 135 kts
Scan Angle .... 30 degrees (±15 from Nadir)
Number of Flights 91
Side Lap (Average) 55%
Scan Frequency .... 51.8 Hz
Laser Pulse Rate .... 120,100 Hz

The LiDAR data for the Area 2 (Cane Creek) AOI was acquired at the following specifications:

Flying Height .... 2,000 Meters AGL
Aircraft Speed .... 135 kts
Scan Angle .... 15 degrees (±7.5 from Nadir)
Number of Flights 72
Side Lap (Average) 55%
Scan Frequency .... 70.7 Hz
Laser Pulse Rate .... 120,100 Hz

Figure 1.2: Airborne LiDAR Flight Line Diagram



The LiDAR data was collected in eleven (11) separate sorties, 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.

During airborne operations, a Global Navigation Satellite System (GNSS) Base Station was deployed at the KHKA, Blytheville, Arkansas Municipal Airport, for the airborne GPS support.

Table 1.1: Airborne LiDAR Acquisition Flight Summary

Airborne LiDAR Acquisition Flight Summary			
Date of Mission	Lines Flown	Mission Time (UTC) Wheels Up/ Wheels Down	Mission Time (Local = CDT) Wheels Up/Wheels Down
April 03, 2010 – Sensor 64	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, and 67-76: Cane Creek	17:01 - 19:55	12:01 - 14:55
April 04, 2010 – Sensor 64	25-60,65, 66, and 79: Cane Creek	11:53 - 17:42	06:53 - 12:42
April 04, 2010 – Sensor 64	61-64, and 77: Cane Creek	22:10 - 23:40	17:10 - 18:40
April 05, 2010 – Sensor 64	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, and 23: Cane Creek	11:47 - 13:30	06:47 - 08:30
April 09, 2010 – Sensor 64	21-52: Middle Ditch	11:50 - 19:10	06:50 - 14:10
April 09, 2010 – Sensor 64	1-20: Middle Ditch 1-7: Cold Creek	19:55 - 02:34	14:55 - 21:34
April 10, 2010 – Sensor 64	8-43: Cold Creek	11:57 - 18:22	06:57 - 13:22
April 10, 2010 – Sensor 64	1-5: Cane Creek Reflights	19:36 - 20:25	14:36 - 15:25
April 13, 2010 – Sensor 64	17, 18, 20, 24, 34, 37, 42, 46, and 49: Middle Ditch Reflights	20:51 - 23:03	15:51 - 18:03
April 14, 2010 – Sensor 64	48, 50, and 53: Middle Ditch Reflights	17:33 - 18:16	12:33 - 13:16
April 15, 2010 – Sensor 64	45 and 47: Middle Ditch Reflights	19:29 - 20:42	14:29 - 15:42

Note, the task order AOIs were collected as three separate LiDAR acquisition blocks. They are listed above as Cane Creek, Cold Creek, and Middle Ditch. The Sharkey Area AOI in Arkansas was identified as Middle Ditch. The Sharkey Area AOI in Tennessee was identified as Cold Creek. The Cane Creek Watershed is the Cane Creek AOI in Tennessee.

SECTION 2: GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)-INERTIAL MEASUREMENT UNIT (IMU) TRAJECTORY INFORMATION

Equipment

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

The LiDAR sensor was equipped with a NovAtel OEM-5 and Honeywell Laseref-V IRS embedded in the sensor IPAS system.

A base-station unit was deployed during each sortie. The base-station setup consisted of NovAtel DL5 GPS/GLONASS L1/L2 receiver, GG702 antenna with a tripod height of 1.75m. The data was collected at 1 Hz.

The base station was KHKA, located at Blytheville Municipal Airport in Arkansas.

Table 2.1: Global Navigation Satellite System (GNSS) Base Station

Station Name	Latitude (DMS)	Longitude (DMS)	Ellipsoid Height (L1 Phase Center) (Meters)
KHKA Primary	N 35° 56' 14.69524"	W 89° 49' 53.00479"	48.989
KHKA Secondary	N 35° 56' 14.82390"	W 89° 49' 52.97891"	48.962

Data Processing

All airborne Global Navigation Satellite System (GNSS) and Inertial Measurement Unit (IMU) data was post-processed and quality controlled using Grafnav Waypoint software and either Applanix POSPac or Leica IPAS software. The Global Navigation Satellite System (GNSS) data was processed at 1 Hz data capture rate and the Inertial Measurement Unit (IMU) data was processed at 200 Hz.

Trajectory Quality

The Global Navigation Satellite System (GNSS) Trajectory, along with high quality Inertial Measurement Unit (IMU) data, is a key factor in determining the overall positional accuracy of the final sensor data.

Flight Trajectory

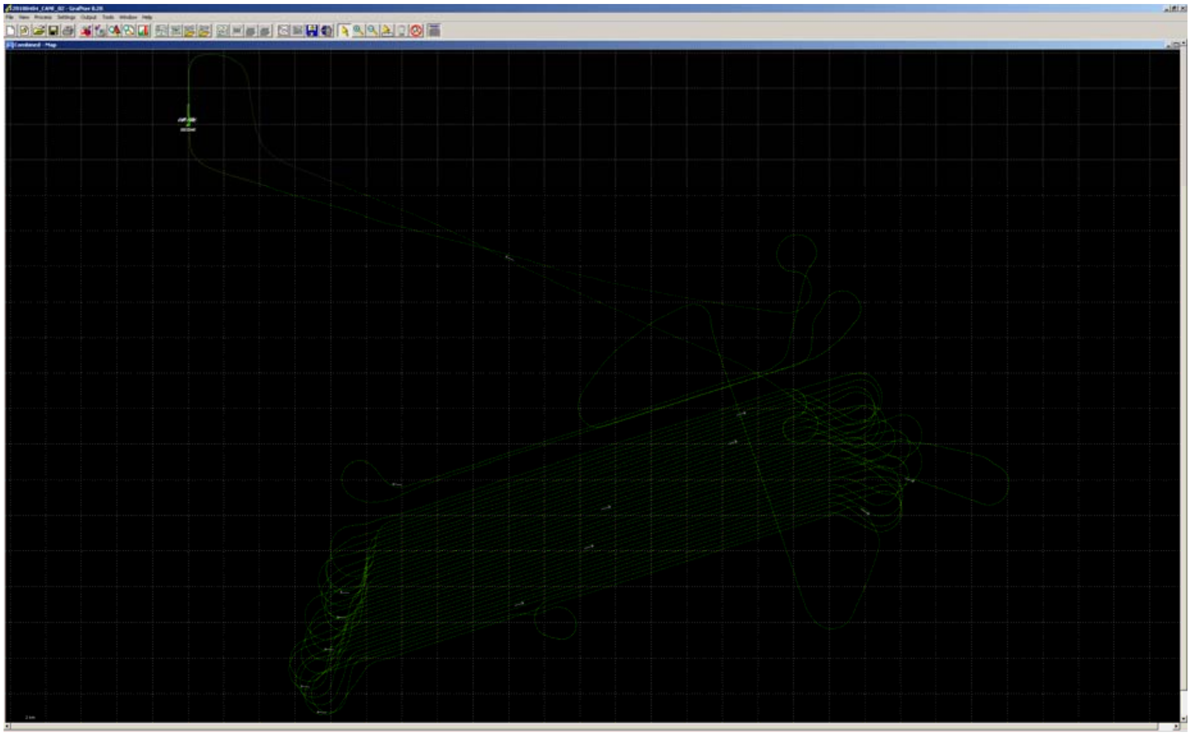


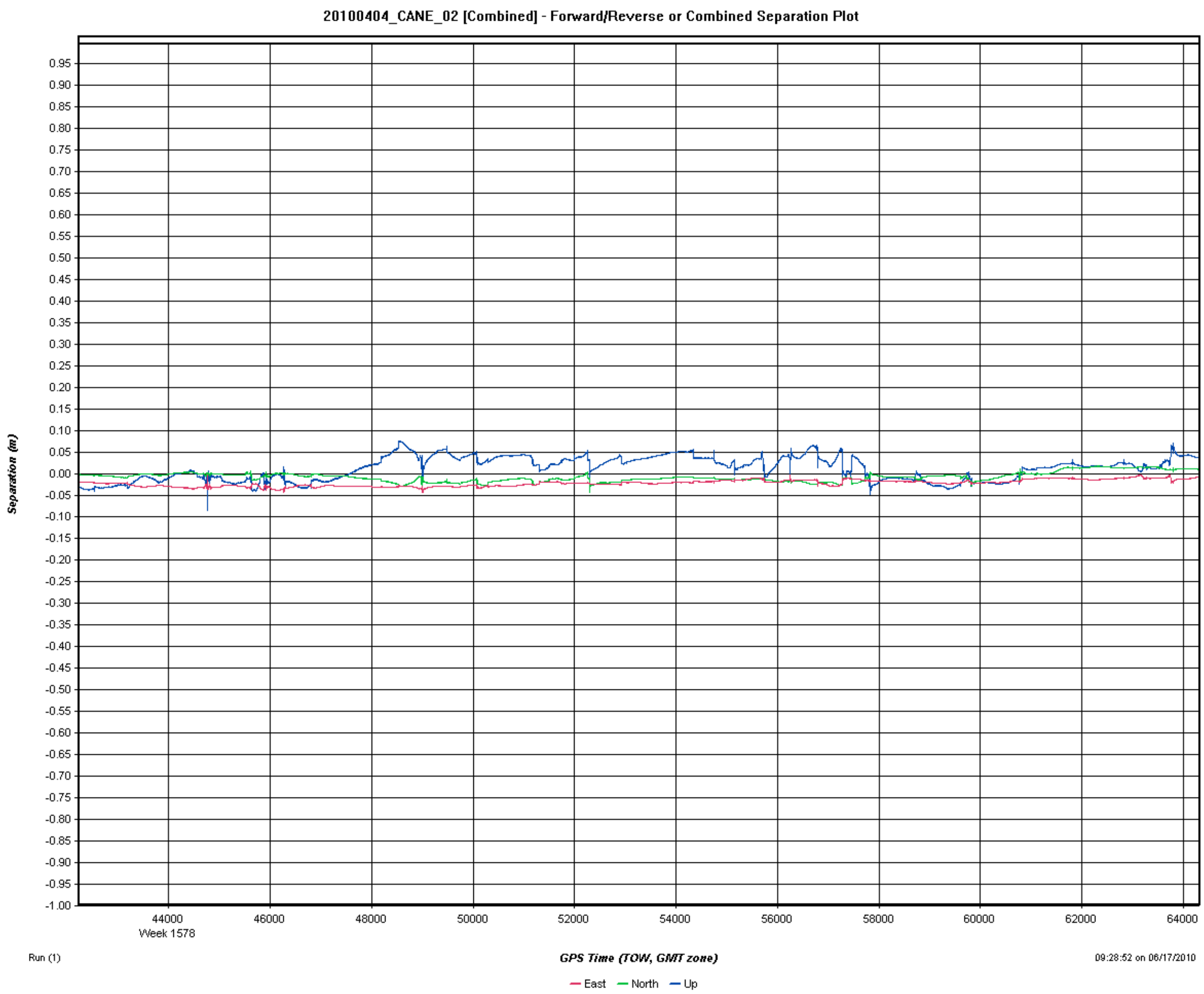
Figure 2.1: Example Graph 20100404_Cane_02 ALS LiDAR S/N64

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).

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 run in both directions to remove directional specific anomalies. The closer these two solutions match; in general, the better is the overall reliability of the solution.

Figure 2.2: Example Graph of Combined Separation

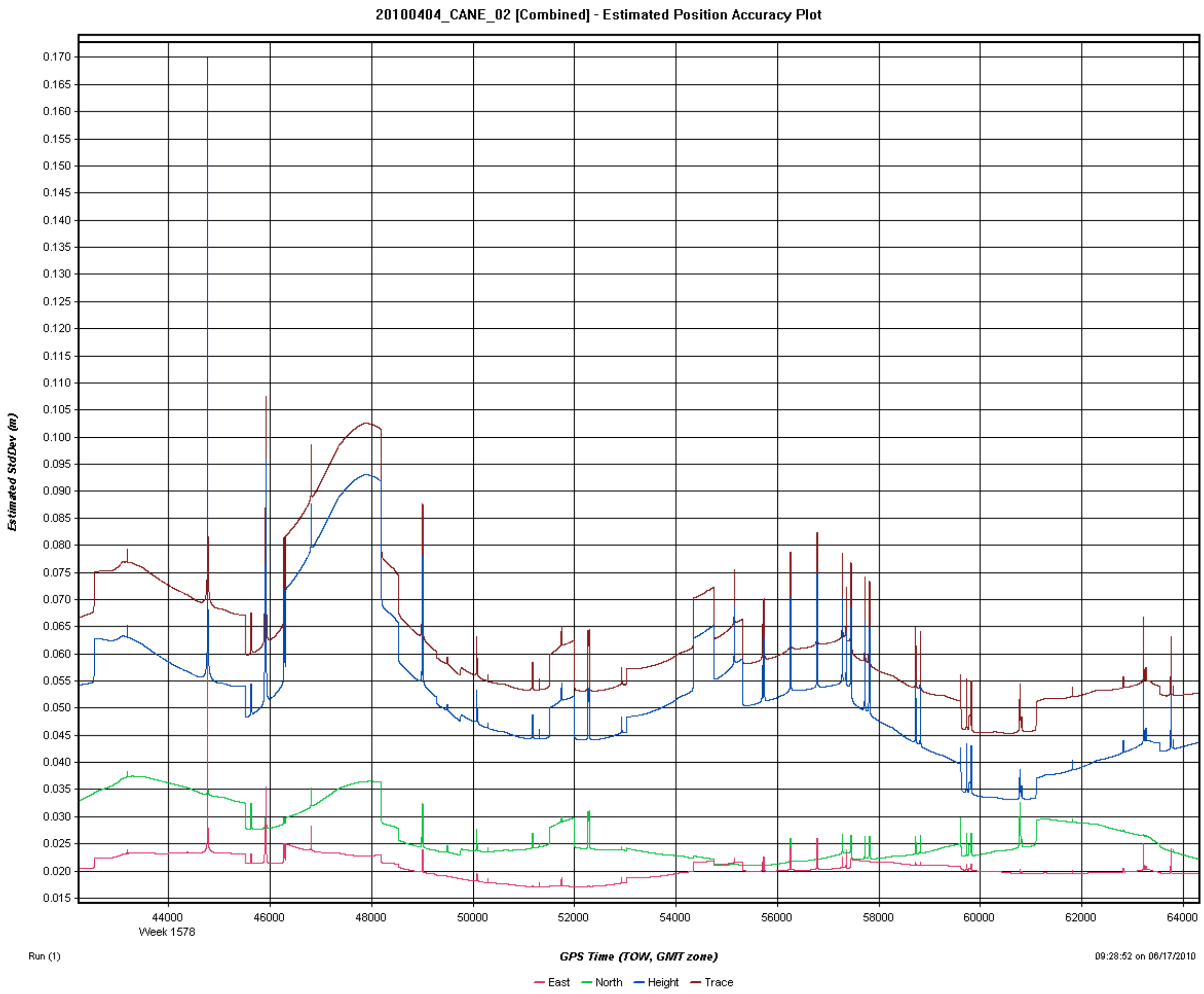


Estimated Positional Accuracy

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 lock issues, as well as issues arising from long baselines, noise, and/or other 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 2.3: Example Graph of Estimated Positional Accuracy



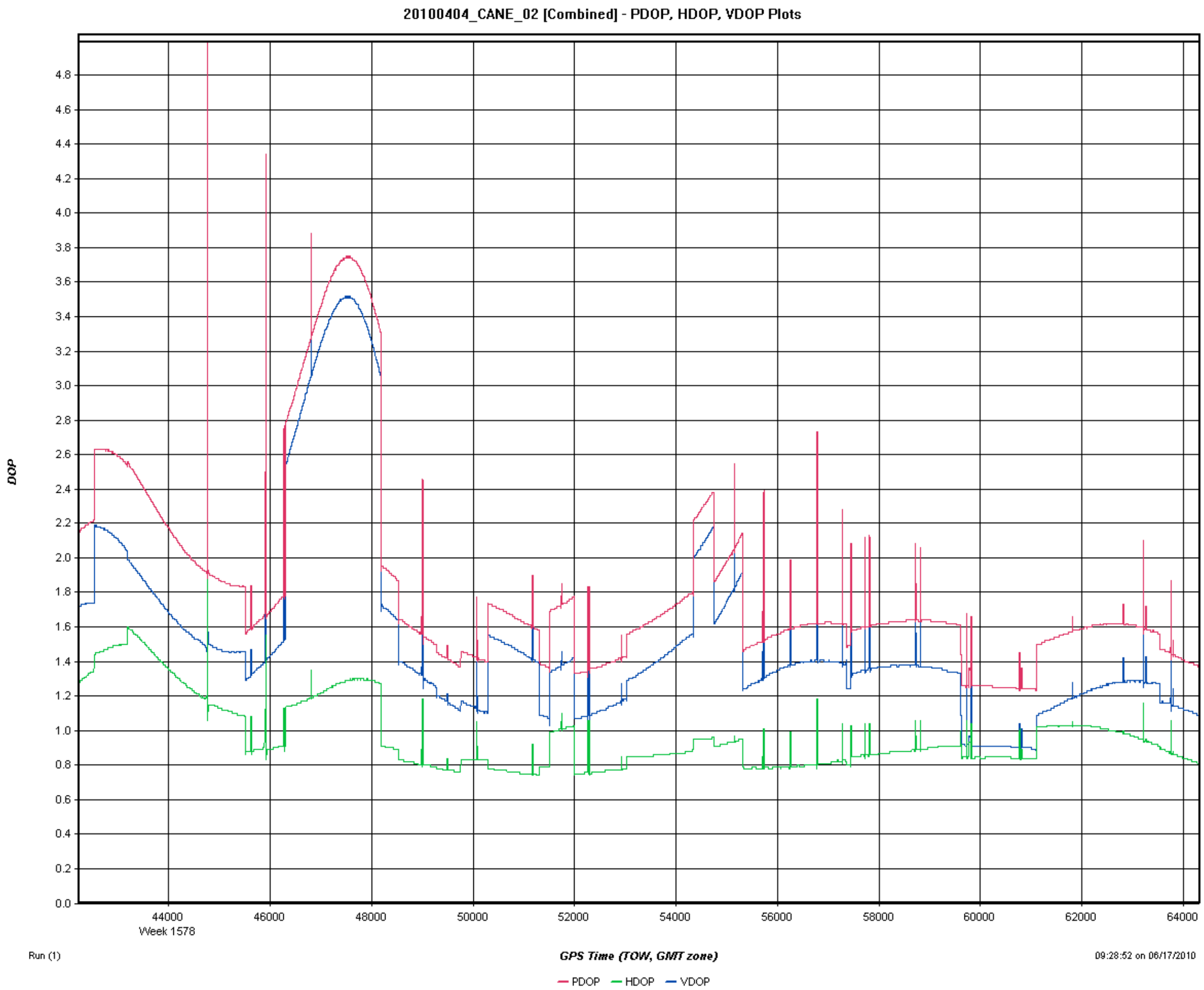
Positional Dilution of Precision (PDOP)

The Positional Dilution of Precision (PDOP) is a factor that describes the effects of satellite geometry on the accuracy of the airborne Global Navigation Satellite System (GNSS) solution. The geometric distribution of the satellites is measured relative to the locations of the receivers on the ground and in the aircraft. Positional Dilution of Precision (PDOP) can be computed in advance, based on the approximate receiver locations and the predicted location of the satellite, which is called the satellite ephemeris.

Low Positional Dilution of Precision (PDOP) values are preferable; the higher the Positional Dilution of Precision (PDOP) value, the weaker the geometric quality of solution between the satellite, aircraft, and reference receivers.

Woolpert's goal is to maintain a final Positional Dilution of Precision (PDOP) of less than three (3) during data acquisition missions. Satellite geometry and the resultant Positional Dilution of Precision (PDOP) levels are dynamic, changing with the position of the aircraft. Occasionally, one satellite in the network will drop below the horizon, breaking its connection to the receiver, and the Positional Dilution of Precision (PDOP) level will spike above three (3) momentarily. Small deviations of this type are accounted for during post-processing of the data through the use of Kalman filtering. If Positional Dilution of Precision (PDOP) value in the aircraft rises above three (3) for a significant time period, the survey is stopped until the geometry improves or the flight is marked for a re-flight, if post processing signifies a significant loss of accuracy due to the Positional Dilution of Precision (PDOP).

Figure 2.4: Example Graph of Positional Dilution of Precision (PDOP)



SECTION 3: FLIGHT LOGS

This section contains the Flight Logs for the task order. The Flight Logs list mission specific details such as crew members, airports, weather conditions, real time Positional Dilution of Precision (PDOP) values and document any issues encountered during the acquisition mission. The Flight Logs are filled out by the sensor operator during the acquisition mission.

The LiDAR data was collected in eleven (11) separate sorties, flown as close together as the weather permitted, to ensure consistent ground conditions across the project area.

Note, the task order AOIs were collected as three separate LiDAR acquisition blocks. They are listed in the flight logs as Cane Creek, Cold Creek, and Middle Ditch. The Sharkey Area AOI in Arkansas was identified as Middle Ditch. The Sharkey Area AOI in Tennessee was identified as Cold Creek. The Cane Creek Watershed is the Cane Creek AOI in Tennessee.

NORTH WEST GROUP

ALS Flight Log

Lift	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KLIT	14:41		KBYH	15:23		0:42	0.7		Transit
2	KBYH	15:37		KHKA	15:43			0.1		Transit
3	KHKA	17:01		KHKA	19:55		2:54	2.9		Production

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1440	2064	16.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
3-Apr-10	10-093	1	ALS50-II	Don Bell			79%	120,100	5.0 / 5.0	ALS500-3	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100403_ CANE_01	FCMS	N27NW	KHKA		15	6,700	135	70.7				3.00 / 3.00	Mini G-1	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Cane Creek							16:52:25	20:07:00					IPAS START/END	11	1.4
Cane Creek							16:54:23	16:55:03					Bit Test #1	11	1.4
Cane Creek							16:55:46	16:56:15					Bit Test #2	11	1.4
Cane Creek							17:08:35	17:13:00	OO	6700	135	70.7	S-turns	11	1.5
Cane Creek	72		1	8			17:14:33	17:16:00	252	6700	135	70.7	Borsite 1-Good Run	11	1.4
Cane Creek	71		10	1			17:26:41	17:28:56	72	6700	135	70.7	SCRUB-Speed	11	1.6
Cane Creek	71		10	1			17:26:41	17:28:56	252	6700	135	70.7	Borsite 2-Good Run	11	1.9
Cane Creek	71		10	1			17:33:39	17:36:13	72	6700	135	70.7	Borsite Bidir	11	1.9
Cane Creek	78		1	13			17:40:35	17:43:00	156	6700	135	70.7	Borsite Parallel-Tieline-Good Run	11	1.9
Cane Creek	2		1	7			17:48:38	17:50:08	72	6700	135	70.7	Good Run	11	1.8
Cane Creek	4		7	1			17:54:48	17:56:00	252	6700	135	70.7	Good Run	11	1.8
Cane Creek	6		1	8			18:00:48	18:02:53	72	6700	135	70.7	Good Run	11	1.7
Cane Creek	8		8	1			18:08:05	18:10:10	252	6700	135	70.7	Good Run	11	1.6
Cane Creek	10		1	9			18:14:08	18:16:00	72	6700	135	70.7	Good Run	10	2.2
Cane Creek	12		8	1			18:20:55	18:23:00	252	6700	135	70.7	Good Run	10	2
Cane Creek	14		1	9			18:26:32	16:28:33	72	6700	135	70.7	Good Run	10	2
Cane Creek	16		9	1			18:32:44	18:34:47	252	6700	135	70.7	Good Run	10	1.9
Cane Creek	18		1	9			18:38:33	18:40:30	72	6700	135	70.7	Good Run	11	1.4
Cane Creek	20		9	1			18:45:03	18:47:15	252	6700	135	70.7	Good Run	12	1.3
Cane Creek	22		1	9			18:50:45	18:52:48	72	6700	135	70.7	Good Run	12	1.3
Cane Creek	24		11	1			18:57:00	18:59:43	252	6700	135	70.7	Good Run	12	1.3
Cane Creek	70		1	16			19:04:48	19:09:00	72	6700	135	70.7	Good Run	12	1.3
Cane Creek	69		17	1			19:13:13	19:17:20	252	6700	135	70.7	Good Run	11	1.4
Cane Creek	68		1	18			19:20:51	19:25:05	72	6700	135	70.7	Good Run	11	1.4
Cane Creek	67		18	1			19:29:33	19:33:53	252	6700	135	70.7	Check Cloud 11 km in. Complete	9	1.7
Cane Creek	73		1	1			19:37:29	19:37:39	72	6700	135	70.7	Good Run	9	1.5
Cane Creek	74		1	1			19:41:57	19:42:15	252	6700	135	70.7	Good Run	9	1.5
Cane Creek	75		1	1			19:45:51	19:46:04	72	6700	135	70.7	Good Run	9	1.5
Cane Creek	76		1	1			19:50:08	19:50:14	252	6700	135	70.7	Good Run	9	1.5
Cane Creek							19:51:00	19:55:00	OO	6700	135	70.7	S-turns	9	1.5

NORTH WEST GROUP

ALS Flight Log

Lift	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	11:53		KHKA	17:42		5:49	5.8		Production
2										
3										

Northwest Job #	Project Name		Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C		Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR		Roch Cherry	064	1070	2	1440	2064	13.0			
Flight Date	**GPS Day**	**Lift # / System**	**Pilot**	**Sun°**	**Solar Times (UTC)**		**Laser Power**	**Pulse Rate**	**Flying Temp °C**		**Data Logger Drive**	**Ant Ht**
4-Apr-10	10-094	2 / ALS50-II	George Ferley				79%	120,100	10.0	10.0	ALS500-3	1.75m
Mission ID (DaySensorJobLift)	**FMS**	**Aircraft**	**Airport ID / UTC**	**FOV**	**Altitude**	**Speed / Scan Hz**	**SW1 / SW2**	**mi / Wpt**	**Altm Setting**		**Download External Drive**	**Rec ID**
20100404_ CANE_02	FCMS	N27NW	KHKA /	15	6,700	135 / 70.7			7.00	12.00	Mini G-1	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Cane Creek							11:43:00	17:50:00					IPAS START/END	9	1.6
Cane Creek							11:45:15	11:45:45					Bit Test #1	9	1.6
Cane Creek							11:46:18	11:46:45					Bit Test #2	9	1.6
Cane Creek							12:01:00	12:03:00	OO	6700	135	70.7	S-turns	8	2.5
Cane Creek	66		18	1			12:04:57	12:09:00	252	6700	135	70.7	Borsite 1-Good Run	8	2.4
Cane Creek	65		1	18			12:12:33	12:16:00	72	6700	135	70.7	Borsite 2-Good Run	8	2.3
Cane Creek	65		9	1			12:21:05	12:23:06	252	6700	135	70.7	Borsite Bidir	8	2
Cane Creek	79		18	1			12:26:33	12:30:00	160	6700	135	70.7	Borsite Parallel-Tieline-Good Run	9	1.4
Cane Creek	26		11	1			12:33:15	12:35:00	252	6700	135	70.7	Good Run	8	1.8
Cane Creek	25		5	1			12:38:14	12:39:00	252	6700	135	70.7	Good Run	8	1.8
Cane Creek	27		1	5			12:42:00	12:47:12	72	6700	135	70.7	Good Run	8	1.9
Cane Creek	28		1	12			12:47:12	12:50:00	72	6700	135	70.7	Good Run	8	1.9
Cane Creek	29		27	1			12:52:40	12:57:50	252	6700	135	70.7	Good Run	8	2.1
Cane Creek	30		1	27			13:01:28	13:07:40	72	6700	135	70.7	Good Run	8	2.1
Cane Creek	31		27	1			13:10:34	13:16:00	252	6700	135	70.7	Good Run	9	2.3
Cane Creek	32		1	27			13:19:29	13:25:00	72	6700	135	70.7	Good Run-PDOP out in end turn.	9	2.1
Cane Creek	33		27	1			13:28:38	13:34:00	252	6700	135	70.7	Good Run	10	2.1
Cane Creek	34		1	27			13:37:34	13:43:00	72	6700	135	70.7	Good Run	10	2
Cane Creek	35		27	1			13:46:40	13:52:00	252	6700	135	70.7	Good Run	10	2
Cane Creek	36		1	27			13:55:41	14:01:00	72	6700	135	70.7	Good Run	9	1.8
Cane Creek	37		28	1			14:04:59	14:11:35	252	6700	135	70.7	Good Run	9	1.8
Cane Creek	38		1	28			14:14:03	14:20:25	72	6700	135	70.7	Good Run	10	1.8
Cane Creek	39		27	1			14:23:41	14:30:02	252	6700	135	70.7	Good Run	10	1.6
Cane Creek	40		1	27			14:32:44	14:38:00	72	6700	135	70.7	Good Run	10	1.6
Cane Creek	41		27	1			14:44:43	14:50:56	252	6700	135	70.7	Good Run	10	1.5
Cane Creek	42		1	27			14:53:38	14:59:50	72	6700	135	70.7	Good Run	10	1.5
Cane Creek	43		26	1			15:02:54	15:08:58	252	6700	135	70.7	Good Run	10	1.5
Cane Creek	44		1	26			15:11:42	15:18:00	72	6700	135	70.7	Good Run	10	2
Cane Creek	45		26	1			15:21:19	15:27:00	252	6700	135	70.7	Good Run	10	1.5
Cane Creek	46		1	26			15:30:12	15:35:56	72	6700	135	70.7	Good Run	9	1.7
Cane Creek	47		25	1			15:39:04	15:44:00	252	6700	135	70.7	Good Run	9	1.7
Cane Creek	48		1	25			15:47:22	15:53:00	72	6700	135	70.7	Good Run	10	1.4
Cane Creek	49		24	1			15:56:05	16:01:40	252	6700	135	70.7	Good Run	10	1.5
Cane Creek	50		1	24			16:04:19	16:10:00	72	6700	135	70.7	Good Run	10	1.5
Cane Creek	51		24	1			16:12:49	16:18:00	252	6700	135	70.7	Good Run	11	1.3
Cane Creek	52		1	24			16:21:07	16:26:00	72	6700	135	70.7	Good Run	10	1.6
Cane Creek	53		24	1			16:29:38	16:35:16	252	6700	135	70.7	Good Run	11	1.4
Cane Creek	54		1	23			16:37:54	16:43:18	72	6700	135	70.7	Good Run	11	1.6
Cane Creek	55		24	1			16:46:18	16:51:45	252	6700	135	70.7	Good Run	11	1.5
Cane Creek	56		1	23			16:54:21	16:59:45	72	6700	135	70.7	Good Run	11	1.5
Cane Creek	57		23	1			17:02:56	17:08:20	252	6700	135	70.7	Good Run	11	1.4
Cane Creek	58		1	23			17:11:11	17:16:00	72	6700	135	70.7	Good Run	11	1.4
Cane Creek	59		22	1			17:19:58	17:25:00	252	6700	135	70.7	Good Run	11	1.7
Cane Creek	60		1	22			17:27:59	17:33:15	72	6700	135	70.7	Good Run	11	1.8
Cane Creek							17:33:25	17:35:33	OO	6700	135	70.7	S-turns	10	1.9

NORTH WEST GROUP

ALS Flight Log

	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	11:53		KHKA	17:42		5:49	5.8		Production
2	KHKA	22:10		KHKA	23:40		1:30	1.5		
3										

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C		Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1440	2064	23.0	23.0		
Flight Date	**GPS Day** / **Lift #** / **System**	**Pilot**	**Sun°**	**Solar Times (UTC)**		**Laser Power**	**Pulse Rate**	**Flying Temp °C**		**Data Logger Drive**	**Ant Ht**
4-Apr-10	10-094 / 3 / ALS50-II	George Ferley				79%	120,100	14.0	10.0	ALS500-3	1.75m
Mission ID (DaySensorJobLift)	**FMS** / **Aircraft**	**Airport ID** / **UTC**	**FOV**	**Altitude**	**Speed** / **Scan Hz**	**SW1** / **SW2**	**mi / Wpt**	**Altm Setting**		**Download External Drive**	**Rec ID**
20100404_ CANE_03	FCMS / N27NW	KHKA /	15	6,700	135 / 70.7	/		0.00	#####	Mini G-1	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Cane Creek							21:59:24						IPAS START/END	8	1.8
Cane Creek							22:03:05	22:03:40					Bit Test #1	8	1.8
Cane Creek							22:04:11	22:04:40					Bit Test #2	8	1.8
Cane Creek							22:14:12	22:17:00	OO	6700	135	70.7	S-turns	7	2.1
Cane Creek	79		18	1			22:21:11		160	6700	135	70.7	Borsite Parallel-Tieline-Good Run	7	2.1
Cane Creek	61		22	1			22:27:45	22:32:57	252	6700	135	70.7	Borsite 1-Good Run	7	2.1
Cane Creek	62		1	21			22:37:20	22:42:00	72	6700	135	70.7	Borsite 2-Good Run	7	2.1
Cane Creek	62		10	1			22:47:22	22:49:00	252	6700	135	70.7	Borsite Bidir	7	2.3
Cane Creek	63		1	21			22:56:01	23:00:54	252	6700	135	70.7	Good Run	7	2.1
Cane Creek	64		19	1			23:04:47	23:09:00	72	6700	135	70.7	Good Run	7	2.3
Cane Creek	77		18	1			23:15:11	23:20:00	198	6700	135	70.7	Good Run	7	2.4
Cane Creek	1									6700	135	70.7	SCRUB	7	2.4
Cane Creek	23									6700	135	70.7	SCRUB	7	2.4
Cane Creek							23:30:00	23:33:00		6700	135	70.7	S-turns	10	1.3

NORTH WEST GROUP

ALS Flight Log

	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA			KHKA						Production
2	KHKA			KHKA						
3										

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1440	2064	19.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
5-Apr-10	10-095	4	ALS50-II	George Ferley			79%	120,100	12.0	ALS500-3	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100405_ CANE_04	FCMS	N27NW	KHKA		15	6,700	135	70.7				9.00	Mini G-1	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Cane Creek							11:42:50						IPAS START/END	8	2.3
Cane Creek							11:46:46	11:47:16					Bit Test #1	8	2.3
Cane Creek							11:47:51	11:48:30					Bit Test #2	8	2.3
Cane Creek							11:59:04	12:02:00	OO	6700	135	70.7	S-turns	8	2.3
Cane Creek	79		15	10			12:04:34	12:05:51	160	6700	135	70.7	Borsite Parallel-Tieline	8	2.3
Cane Creek	69		13	17			12:09:13	12:10:23	252	6700	135	70.7	Borsite 1	8	2.3
Cane Creek	68		13	17			12:16:30	12:18:00	72	6700	135	70.7	SCRUB	8	2.3
Cane Creek	68		13	17			12:16:30	12:18:00	72	6700	135	70.7	Borsite 2	8	2.3
Cane Creek	68		17	13			12:23:27	12:24:00	252	6700	135	70.7	Borsite Bidir	8	2.1
Cane Creek	23		4	1			12:29:02	12:30:00	252	6700	135	70.7	Good Run	8	1.8
Cane Creek	21		1	4			12:32:41	12:33:00	72	6700	135	70.7	SCRUB Speed	8	1.8
Cane Creek	21		4	1			12:38:35	12:39:00	252	6700	135	70.7	Good Run	8	2.1
Cane Creek	19		1	4			12:43:03	12:43:50	72	6700	135	70.7	Good Run	8	1.9
Cane Creek	17		4	1			12:48:06	12:48:57	252	6700	135	70.7	Good Run	8	2
Cane Creek	15		1	5			12:52:47	12:53:41	72	6700	135	70.7	Good Run	8	2.1
Cane Creek	13		4	1			12:57:34	12:58:35	252	6700	135	70.7	Good Run	8	2.1
Cane Creek	11		1	5			13:02:00	13:03:00	72	6700	135	70.7	Good Run	9	1.6
Cane Creek	9		4	1			13:07:01	13:07:54	252	6700	135	70.7	PDOP 13:04 in turn. Good Run	9	1.6
Cane Creek	7		2	1			13:11:22	13:11:38	72	6700	135	70.7	PDOP 13:09 in turn. Good Run	9	2.3
Cane Creek	5		1	1			13:14:12	13:15:22	252	6700	135	70.7	Good Run	9	2.3
Cane Creek	3		1	1			13:18:57	13:19:07	72	6700	135	70.7	Good Run	9	2.1
Cane Creek	1		1	1			13:22:48	13:22:58	252	6700	135	70.7	Good Run	9	2.1
Cane Creek	21		1	4					72	6700	135	70.7	Good Run-Reflight from first attempt.	9	2.1
							13:30:00	13:35:00	OO	6700	135	70.7	S-turns		

NORTH WEST GROUP

ALS Flight Log

	Lift Begin Airport	Lift Begin AB	Lift Begin Hobbs	Lift End Airport	Lift End Land	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	11:50		KHKA	19:10		7:20	7.3		Production
2										
3										

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C		Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-Lidar	Stew Freeman	064	1070	2	1415	2016	5.0	19.0		KHKA

Flight Date	GPS Day	Lift	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C		Data Logger Drive	Ant Ht
9-Apr-10	10-099	6	ALS50-II	George Ferley			77%	122,500	1.0	7.0	ALS500-4	1.75M

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	km/WPT	Altm Setting		Download External Drive	Rec ID
20100409_MD_06	FCMS	N27NW	KHKA	-5	30	6,700	135	51.8	12	2		30.09	30.16	mini G06:BU 02	2

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Lidar #1 DL5 0002 Comments and Conditions Lidar #2 DL5 0004	SVs	PDOP
Middle Ditch							11:40:16	11:45:00					Static ipas on 100409_143815		
							11:43:00						bit test #1		
							11:44:00						bit test #2		
							11:55:00						S-turns SKC Haze 3		
	51				8	0	12:02:00	12:03:50	223	6335	142			7	2.4
	52				9	9	12:07:37	12:09:50	223	6335	130			7	1.8
	50				0		12:11:00	12:13:00	043	6335	142		abort due spd, go arnd. Scrub first data	7	1.8
	50				0	11	12:18:45	12:22:00	043	6360	136			7	1.8
	49				0	8	12:25:00	12:27:00	043	6360	139			7	2.1
	47				8	0	12:29:00	12:31:00	223	6350	135			7	2.1
	48				13	0	12:35:00	12:38:00	223	6350	136			7	2.1
	46				0	15	12:40:00	12:44:00	043	6350	139			7	2.2
	45				0	9	12:47:00	12:49:00	043	6350	137			8	1.6
	44				37	0	12:51:00	13:00:00	223	6350	136			7	2.4
	43				0	38	13:02:00	13:11:37	043	6390	140			8	2.2
	42				33	0	13:14:28	13:23:36	223	6390	137			9	2.1
	41				0	39	13:25:50	13:34:50	043	6350	139			9	2
	40				39	0	13:41:45	13:52:00	223	6400	127		miss @ 13:37 go around. Scrub first data	9	1.9
	38				0	51	13:53:29	14:05:15	043	6385	140			9	1.6
	39				40	0	14:10:00	14:19:40	223	6360	130			9	1.6
	37				0	51	14:23:10	14:34:50	043	6360	137			9	1.6
	36				51	0	14:38:00	14:50:00	223	6370	140			9	1.5
	35				0	52	14:52:40	15:05:00	043	6430	143			9	2.1
	34				52	0	15:07:40	15:20:00	223	6350	134			9	1.7
	33				0	52	15:22:40	15:35:00	043	6380	136			10	1.4
	32				53	0	15:37:50	15:50:30	223	6380	136			10	1.8
	31				0	53	15:52:50	16:05:25	043	6390	137			10	1.5
	30				53	0	16:08:20	16:20:57	223	6330	141			11	1.6
	29				0	54	16:24:50	16:37:20	043	6350	136			11	1.6
	28				54	0	16:40:00	16:53:00	223	6340	136			11	1.4
	27				0	55	16:55:15	17:08:20	043	6360	140			10	1.8
							17:09:00	17:10:00	OO	6330			S turns	11	1.8
	29				54	44	17:11:15	17:13:45	223	6330	134		BIDIR	11	1.8
TL	55				14	0	17:18:10	17:21:20	NW	6310	140		X-line	11	1.8
							17:22:00	17:24:00	OO	6320			S turns	11	2
	26				56	0	17:25:20	17:38:00	223	6350	135			11	1.3
	25				0	57	17:41:00	17:55:00	043	6340	134			11	1.7
	24				57	0	17:57:00	18:11:00	223	6340	135			10	2.1
	23				0	58	18:16:00	18:30:00	043	6350	137		18:13 miss go around. Scrub 1st data	10	1.9
	22				59	0	18:32:15	18:46:20	223	6330	136			12	1.3
	21				0	59	18:48:35	19:02:35	043	6360	133			11	2
							19:03:00	19:05:00	OO				S turns	11	1.4
							19:11:00	19:16:00					static		
							19:17:00						ipas off		

NORTH WEST GROUP

ALS Flight Log

	Lift Begin			Lift End			Flt	Flt	Hobbs	
	Airport	Chocks	Hobbs	Airport	Chocks	Hobbs	Duration	Hrs	Hrs	Actvity
1	KHKA	19:55		KHKA	2:34		6:39	6.7		Production
2	KHKA			KHKA						Production
3	KHKA			KHKA						Production

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1415	2016	20.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
9-Apr-10	10-099	7	ALS50-II	Don Bell			77%	122,500	5.0 / 12.0	ALS500-3	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100409_MD_CLC_07	FCMS	N27NW	KHKA		30	6,700	135	51.8	12	2		16.00 / 6.00		

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Middle Ditch							19:47:30						IPAS START/END	8	1.8
Middle Ditch							19:50:46	19:51:40					Bit Test #1	8	1.8
Middle Ditch							19:52:17	19:52:50					Bit Test #2	8	1.8
Middle Ditch							20:00:00	20:04:00	OO	6350	135	51.8	S-turns	8	1.9
Middle Ditch	55		0	8			20:12:46	20:14:44	131	6350	135	51.8	Borsite 1-Good Run Tieline	8	1.9
Middle Ditch	20		0	60			20:19:38	20:34:00	222	6350	135	51.8	Borsite 2-Good Run	8	1.9
Middle Ditch	19		60	0			20:37:40	20:52:00	42	6350	135	51.8	Borsite 2-Good Run	8	1.9
Middle Ditch	19		0	8			20 55:46	20:57:00	222	6350	135	51.8	Borsite Bidir	8	1.9
Middle Ditch	18		0	60			21:03:21	21:18:00	222	6350	135	51.8	Good Run	9	1.5
Middle Ditch	17		61	0			21:24:33	21:39:00	42	6350	135	51.8	Good Run-Check for a couple of gaps north half of line.	8	1.9
Middle Ditch	16		0	61			21:42:50	21:58:00	222	6350	135	51.8	Good Run	8	1.8
Middle Ditch	15		61	0			22:01:22	22:16:00	42	6350	135	51.8	Good Run	9	1.5
Middle Ditch	14		0	61			22:19:49	22:34:28	222	6350	135	51.8	Good Run	8	2.0
Middle Ditch	13		60	0			22:37:56	22:53:00	42	6350	135	51.8	Good Run	8	2.0
Middle Ditch	12		0	49			22:57:05	23:09:00	222	6350	135	51.8	Good Run	9	1.8
Middle Ditch	11		49	0			23:13:15	23:24:57	42	6350	135	51.8	Good Run	9	1.8
Middle Ditch	10		0	36			23:28:01	23:36:00	222	6350	135	51.8	Good Run	10	1.4
Middle Ditch	9		35	0			23:38:46	23:47:00	42	6350	135	51.8	Good Run	9	1.6
Middle Ditch	8		0	30			23:49:45	23:57:00	222	6350	135	51.8	Good Run	9	1.9
Middle Ditch	7		29	0			00:00:30	00:07:00	42	6350	135	51.8	Good Run	8	2.2
Middle Ditch	6		0	26			00:10:32	00:16:00	222	6350	135	51.8	Good Run	9	1.7
Middle Ditch	5		25	0			00:20:03	00:25:50	42	6350	135	51.8	Good Run	10	1.6
Middle Ditch	4		0	17			00:29:28	00:33:15	222	6350	135	51.8	Good Run	10	1.7
Middle Ditch	3		14	0			00:36:26	00:39:40	42	6350	135	51.8	Good Run	10	1.7
Middle Ditch	2		0	12			00:42:46	00:45:32	222	6350	135	51.8	Good Run	10	1.7
Middle Ditch	1		10	0			00:48:50	00:51:00	42	6350	135	51.8	Good Run	10	1.7
Middle Ditch	54		0	21			00:54:44	01:00:00	129	6350	135	51.8	Good Run	10	1.7
Middle Ditch	53		25	0			01:04:45	01:10:30	271	6350	135	51.8	Good Run- **Block flown to Completion.**	10	1.6
Cold Creek													**Change to Cold Creek Project**	8	2.1
Cold Creek	44		17	1			1:23:15AM	01:27:13	133	6350	135	51.8	Good Run	8	2
Cold Creek	1		0	12			01:32:18	01:35:00	49	6350	135	51.8	Good Run	8	2
Cold Creek	2		14	0			01:38:49	01:42:00	133	6350	135	51.8	Good Run	8	1.8
Cold Creek	3		0	17			01:46:30	01:50:25	49	6350	135	51.8	Good Run	8	1.8
Cold Creek	4		17	0			01:53:55	01:56:47	133	6350	135	51.8	Good Run	9	1.7
Cold Creek	5		0	18			02:01:44	02:05:57	49	6350	135	51.8	Good Run	9	2.1
Cold Creek	6		19	0			02:09:33	02:14:00	133	6350	135	51.8	Good Run	9	2.3
Cold Creek	7		0	29			02:17:13	02:24:00	49	6350	135	51.8	Good Run	9	2.2
Cold Creek							02:24:00	02:27:00	OO	6350	135	51.8	S-turns	9	2.2

NORTH WEST GROUP

ALS Flight Log

	Lift Begin			Lift End			Flt	Flt	Hobbs	
	Airport	AB	Hobbs	Airport	Land	Hobbs	Duration	Hrs	Hrs	Actvity
1	KHKA	11:57		KHKA	18:22		6:25	6.4		Production
2										
3										

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-Lidar	Stew Freeman	064	1070	2	1415	2016	11.0 / 22.0		KHKA

Flight Date	GPS Day	Lift	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
10-Apr-10	10-100	8	ALS50-II	George Ferley	NA	NA	77%	122,500	5.0 / 4.0	ALS 500-4	1.75M

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	km/WPT	Altm Setting	Download External Drive	Rec ID
20100410_cold_08	FCMS	N27NW	KHKA	-5	30	6,350	135	51.8	12	2		30.27 / 30.28	Mini G-04: B up 02	2

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Lidar #1 DL5 0002 Comments and Conditions Lidar #2 DL5 0004	SVs	PDOP
Cold Creek							11:47:40						Static ipas on		
							11:50:00						Bit #1 test		
							11:51:00						Bit # 2 test		
							12:03:00	12:05:00	OO				S turns SKC Hz 2	8	2.2
TL	45				0	15	12:08:53	12:12:18	326	6385	136		12:06 Z miss, go around	8	1.8
TL	46				11	0	12:15:28	12:18:11	129	6390	130		X-line	8	1.9
	10				35	0	12:21:15	12:29:35	229	6410	138			8	1.9
	9				0	31	12:32:35	12:39:50	049	6380	137			8	2.2
	8				30	0	12:42:55	12:49:50	229	6360	136			9	22.2
	11				0	41	12:52:29	13:02:16	049	6370	131			8	2.3
	12				41	0	13:04:56	13:14:44	229	6360	134			9	2.1
	13				0	41	13:17:38	13:27:13	049	6357	138			9	2
	13				41	31	13:30:32	13:33:00	229	6330	136		BIDIR	10	1.9
	14				41	0	13:38:15	13:47:40	229	6400	133			10	1.7
	15				0	41	13:50:46	14:00:13	049	6360	140			10	1.6
	16				41	0	14:03:24	14:12:38	229	6380	130			10	1.5
	17				0	41	14:15:38	14:25:17	049	6380	137			10	1.7
	18				42	0	14:26:04	14:37:40	229	6360	138			10	1.5
	19				0	43	14:40:33	14:50:38	049	6365	137			10	1.5
	20				44	0	14:53:26	15:03:30	229	6340	133			10	1.5
	21				0	44	15:06:33	15:16:45	049	6360	137			9	1.7
	22				45	0	15:19:51	15:30:00	229	6360	133			9	1.7
	23				0	45	15:33:06	15:43:30	049	6360	138			10	1.5
	24				45	0	15:46:31	15:57:05	229	6330	132			10	1.5
	25				0	45	15:59:51	16:10:20	049	6360	137			11	1.4
	26				45	0	16:13:16	16:23:35	229	6340	135			11	1.5
	27				0	45	16:27:43	16:38:21	049	6350	132			11	1.5
	29				19	0	16:41:12	16:45:22	229	6330	134			11	1.4
	31				0	18	16:48:11	16:52:15	049	6330	138			11	1.4
	33				18	0	16:55:19	16:59:00	229	6330	140			10	1.8
	35				0	17	17:02:36	17:06:20	049	6340	140			11	1.8
	37				16	0	17:09:24	17:13:00	229	6340	130			11	1.8
	39				0	15	17:15:58	17:19:20	049	6340	138			11	1.8
	41				8	0	17:22:38	17:24:45	229	6320	136			11	1.8
	43				0	7	17:27:06	17:28:20	049	6340	139			11	1.7
	28				13	0	17:36:09	17:39:00	229	6320	138			11	1.7
	30				0	13	17:41:56	17:44:37	049	6330	135			11	1.7
	32				12	0	17:48:00	17:50:37	229	6360	139			11	1.6
	34				0	11	17:53:32	17:55:46	049	6330	140			10	2.2
	36				9	0	17:59:04	18:01:12	229	6330	136			10	2
	38				0	7	18:04:02	18:05:22	049	6340	136			10	1.9
	40				6	0	18:08:28	18:09:44	229	6330	135			12	1.3
	42				0	6	18:12:53	18:35:00	049	6330	135			12	1.3
							18:14:00	18:16:00	OO				S turns		
							18:24:00	18:29:00					Static		
							18:30:00						ipas off		

	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	19:36		KHKA	20:25		0:49	0.8		Production
2										
3										

NORTH WEST GROUP

ALS Flight Log

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1440	2064	23.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
10-Apr-10	10-100	9	ALS50-II	Don Bell			79%	120,100	4.0 / 4.0	ALS500-3	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100410_ CANE_09	FCMS	N27NW	KHKA		15	6,700	135	70.7				28.00 / 12.00	Mini G-	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Cane Creek							19:29:30	20:36:00					IPAS START/END	10	1.4
Cane Creek							19:31:45	19:32:15					Bit Test #1	10	1.4
Cane Creek							19:32:48	19:33:15					Bit Test #2	10	1.4
Cane Creek							19:46:00	19:48:00	OO	6700	135	70.7	S-turns	10	1.4
Cane Creek	5		0	5			19:49:47	19:50:47	72	6700	135	70.7	Borsite 1-Good Run	9	1.7
Cane Creek	4		0	9			19:53:52	19:56:00	252	6700	135	70.7	Good Run	9	1.7
Cane Creek	2		0	7			20:00:05	20:01:35	72	6700	135	70.7	Good Run	8	1.9
Cane Creek	3		5	0			20:05:19	20:06:18	252	6700	135	70.7	Borsite 2-Good Run	8	1.8
Cane Creek	1		0	2			20:10:16	20:10:40	72	6700	135	70.7	Good Run	8	1.8
Cane Creek	5		5	0			20:15:06	20:16:05	252	6700	135	70.7	Borsite Bidir	8	1.8
Cane Creek	77		0	7			20:20:27	20:22:00	72	6700	135	70.7	Borsite Tieline	8	1.7
Cane Creek							20:22:00	20:25:00	72	6700	135	70.7	S-turns	8	1.7
													Cane Creek Block Compelte.		

NORTH WEST GROUP

ALS Flight Log

	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	20:51		KHKA	23:03		2:12	2.2		Production
2	KHKA			KHKA						Production
3	KHKA			KHKA						Production

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1415	2016	26.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
13-Apr-10	10-103	10	ALS50-II	Don Bell			77%	122,500	10.0 / 10.0	ALS500-04	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100410_MD_10	FCMS	N27NW	KHKA		30	6,700	135	51.8	12	2		23.00 / 23.00	Mini G-2	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Middle Ditch							20:32:15						IPAS START/END	8	1.8
Middle Ditch							20:37:21	20:38:10					Bit Test #1	8	1.8
Middle Ditch							20:39:14	20:40:25					Bit Test #2	8	1.8
Middle Ditch							20:56:00	21:04:00	OO	6350	135	51.8	S-turns	8	1.9
Middle Ditch	24		40	57			21:01:44		42	6350	135	51.8	SCRUB	8	1.9
Middle Ditch	17		61	40					222	6350	135	51.8	SCRUB	8	1.9
Middle Ditch	24		40	57			21:18:29	21:22:00	42	6350	135	51.8	Good Run	8	1.9
Middle Ditch	17		61	40			21:26:31	21:31:45	222	6350	135	51.8	Good Run	8	1.9
Middle Ditch	20		45	0			21:37:39	21:50:00	42	6350	135	51.8	Borsite 1 Good Run	9	1.5
Middle Ditch	18		0	10			21:52:33	21:55:00	222	6350	135	51.8	Borsite 2 Good Run	7	1.8
Middle Ditch	18		10	0			21:59:13	22:03:00	42	6350	135	51.8	Bidir	7	1.8
Middle Ditch	53		25	0			22:06:00	22:13:00	222	6350	135	51.8	X-Track	9	1.5
Middle Ditch	49		0	8			22:17:00	22:19:00	42	6350	135	51.8	Good Run-Complete line	8	2.0
Middle Ditch	46		14	1			22:24:46	22:29:00	222	6350	135	51.8	Good Run. Flew additional to RF list.	8	2.0
Middle Ditch	42		0	26			22:32:28	22:39:00	42	6350	135	51.8	Good Run last third water	9	1.8
Middle Ditch	37		13	0			22:44:09	22:47:00	222	6350	135	51.8	Good Run	9	1.8
Middle Ditch	34		0	13			22:51:29	22:54:00	42	6350	135	51.8	Good Run	10	1.4
Middle Ditch							22:54:00	22:57:00	OO	6350	135	51.8	S-turns	9	1.6

NORTH WEST GROUP

ALS Flight Log

Lift	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	17:33		KHKA	18:16		0:43	0.7		Production
2	KHKA			KHKA						Production
3	KHKA			KHKA						Production

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1415	2016	27.0 / 28.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
14-Apr-10	10-104	10	ALS50-II	George Ferley			77%	122,500	10.0 / 10.0	ALS500-04	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100414_MD_11	FCMS	N27NW	KHKA		30	6,700	135	51.8	12	2		35.00 / 34.00	Mini G-5	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Middle Ditch							17:25:40	18:25:00					IPAS START/END	11	2.0
Middle Ditch							17:27:00	17:27:30					Bit Test #1	11	1.9
Middle Ditch							17:28:03	17:29:00					Bit Test #2	11	1.9
Middle Ditch							17:39:22	17:43:00	OO	6350	135	51.8	S-turns	11	1.9
Middle Ditch	50		0	11			17:45:01	17:47:00	222	6350	135	51.8	Borsite 1 Good Run	11	1.9
Middle Ditch	50		11	0			17:50:54	17:53:26	42	6350	135	51.8	Bidir	12	1.3
Middle Ditch	48		0	13			17:56:24	17:59:00	222	6350	135	51.8	Borsite 2 Good Run	12	1.3
Middle Ditch	53		10	0			18:05:18	18:07:00	222	6350	135	51.8	X-Track	12	1.3
Middle Ditch							18:07:00	18:10:00	OO	6350	135	51.8	S-turns	12	1.3

NORTH WEST GROUP

ALS Flight Log

Lift	Lift Begin Airport	Lift Begin Chocks	Lift Begin Hobbs	Lift End Airport	Lift End Chocks	Lift End Hobbs	Flt Duration	Flt Hrs	Hobbs Hrs	Actvity
1	KHKA	19:29		KHKA	20:42		1:13	1.2		Production
2	KHKA			KHKA						Production
3	KHKA			KHKA						Production

Northwest Job #	Project Name	Operator	Unit	IMU	MPiA	Min Range'	Max Range'	Ground Temp°C	Shipping Track Number	Base ID
10-702	Woolpert-AR/TN-LIDAR	Roch Cherry	064	1070	2	1415	2016	28.0		

Flight Date	GPS Day	Lift #	System	Pilot	Sun°	Solar Times (UTC)	Laser Power	Pulse Rate	Flying Temp °C	Data Logger Drive	Ant Ht
15-Apr-10	10-105	12	ALS50-II	George Ferley			77%	122,500	10.0 / 10.0	ALS500-04	1.75m

Mission ID (DaySensorJobLift)	FMS	Aircraft	Airport ID	UTC	FOV	Altitude	Speed	Scan Hz	SW1	SW2	mi / Wpt	Altm Setting	Download External Drive	Rec ID
20100415_MD_12	FCMS	N27NW	KHKA		30	6,700	135	51.8	12	2		30.00 / 30.00	Mini G-2	

Area	Flight # NWG	Flight # Client's	Wpt From	Wpt To	Distance Begin	Distance End	UTC Start	UTC End	Flt Dir	Altitude (feet)	Speed (knots)	Scan Rate	Comments and Conditions	SVs	PDOP
Middle Ditch							19:19:57	20:50:31					IPAS START/END	8	1.9
Middle Ditch							19:25:31	19:26:00					Bit Test #1	8	1.9
Middle Ditch							19:26:30	19:27:05					Bit Test #2	8	1.9
Middle Ditch							19:35:00	19:38:00	OO	6350	135	51.8	S-turns	8	1.9
Middle Ditch	20		47	0			19:42:09	19:54:00	222	6350	135	51.8	Borsite 1 Good Run	8	2.1
Middle Ditch	20		0	0			19:57:18		42	6350	135	51.8	SCRUB	8	2.1
Middle Ditch	20		47	10			20:11:04	20:23:00	42	6350	135	51.8	Bidir	8	2.1
Middle Ditch	19		45	37			20:27:13	20:29:00	222	6350	135	51.8	Borsite 2 Good Run	8	2.1
Middle Ditch	54						20:34:22	20:36:00	129	6350	135	51.8	X-Track	8	1.5
							20:36:00		OO				S-turns		

SECTION 4: LIDAR SYSTEM SPECIFICATIONS

The LiDAR data was acquired using a Leica ALS50-II 150 kHz Multiple Pulses in Air (MPiA) LiDAR sensor system, on board a Cessna 406. The ALS50-II MPiA 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 ALS50-II 150 kHz MPiA LiDAR System has the following specifications:

Table 4.1: ALS50-II MPiA LiDAR System Specifications

Specification	
Operating Altitude	200 - 6,000 meters
Scan Angle	0 to 75° (variable)
Swath Width	0 to 1.5 X altitude (variable)
Scan Frequency	0 – 90 Hz (variable based on scan angle)
Maximum Pulse Rate	150 kHz
Range Resolution	Better than 1 cm
Elevation Accuracy	8 – 24 cm single shot (one standard deviation)
Horizontal Accuracy	7 – 64 cm (one standard deviation)
Number of Returns per Pulse	4 (first, second, third, last)
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

Antenna Offsets

Aircraft GPS Antenna

The following measurements were calculated for North West's aircraft N27NW Cessna Caravan-II F406 equipped with the Leica ALS50-II MPiA LiDAR system. The POS/AV and ALS50-II processing numbers were calculated from internal measurements completed in Leica's lab.

The following measurements were calculated in the lab at Leica and will remain constant.

Table 4.2: ALS50-II S/N 64

User to IMU Lever Arm (POS/AV)	
X	-0.269 m
Y	0.207 m
Z	-0.004 m

The positioning of the GPS antenna on the aircraft was field surveyed using a total station.

Table 4.3: N27NW: Cessna 406 with ALS50-II S/N 64 installed

Reference Point to GPS Antenna	
X	1.069 m
Y	-0.016 m
Z	-1.177 m

Base Station GPS Antenna

Table 4.4: Base Station Global Navigation Satellite System (GNSS) Equipment

Monument Description	
GPS Receiver Type: NovAtel DL5 GPS/GLONASS L1/L2 Receiver Antenna Type: NovAtel GG702 Antenna	Epoch Interval: 0.5 sec Elevation Mask: 10 degrees Observation Type: Static
Station Names used in processing the acceptance data: #1: KHKA Primary N 35 56 14.69534 Lat. W 89 49 53.00499 Long. 48.946 m Ellipsoidal Height #2: KHKA Secondary N 35 56 14.82390 Lat. W 89 49 52.97891 Long. 48.962 m Ellipsoidal Height #3: CORS EDM2 N 35 26 57.18172 Lat. W 89 46 52.30460 Long. 108.446 m Ellipsoidal Height	

Calibration Results

Final Calibration Parameters

The following numbers were derived by Leica through lab calibration, as well as from data acquired over the project site. These are the latest pertinent values for the respective sensor and project.

Table 4.5: Final Calibration Parameters for ALS50-II S/N 64

Parameter	Value	Format
Lab fixed parameters		
Range 1 Correction	1.979/1.979 m	0.000
Range 2 Correction	2.000/1.958 m	0.000
Range 3 Correction	1.996/2.009 m	0.000
Range 4 Correction	1.977/1.951 m	0.000
Encoder Latency	0.00 mcr sec	0.00
Ticks Per Revolution	150000 ticks	0000000
Attitude		
*Roll (radian)	-0.00122	0.000000000
*Pitch (radian)	0.00893	0.000000000
*Heading (radian)	-0.00155	0.000000000
*Scan angle correct	-10200 ticks	00000
Mechanic		
*Torsion (no unit)	-70000	00000

*Value calibrated on site from calibration data
*Values from lift 20100413_MD_10

SECTION 5: DATA PROCESSING AND QUALITY CONTROL

LiDAR Data Processing

In this process, Woolpert employed GPS differential processing and Kalman filtering techniques to derive an aircraft trajectory solution at one or half-second intervals for each base station within the project limits. Statistics for each solution (base station) were generated and studied for quality. The goal for each solution is to have:

- maintained satellite lock throughout the session
- position standard deviation of less than 10 centimeters
- low ionospheric noise
- few or no cycle slips
- a fixed integer ambiguity solution throughout the trajectory
- a maximum number of satellites for a given constellation
- a low (3.0 or less) Position Dilution of Precision (PDOP)

Often times a solution for a given base station will meet all of the above parameters in certain portions of the trajectory while the other base station might meet the above conditions in different portions of the trajectory solution. In this case, further processing was done to form different combinations of base station solutions and/or satellites to arrive at the optimal trajectory.

When the calibration, data acquisition, and GPS processing phases were complete, the formal data reduction processes by Woolpert LiDAR specialists include:

- Processed individual flight lines to derive the “Point Cloud.”
- Given the airborne GPS aircraft trajectory and the raw LiDAR data subdivided by flight lines, we used manufacturer software to reduce raw information to a LiDAR point cloud on the ground. Woolpert has developed proprietary software to generate parameter files, allowing the manufacturer’s software to process a block; which allows us to batch process any number of flight lines. As part of this process, outliers in the data are removed.
- Examined the individual flight lines and how these lines match adjacent flight lines to ensure the accuracy meets expectations.
- Overlap match individual flight lines, generated statistics on the fit, and make the necessary adjustments.
- Identified and removed systematic error locally (by flight) which is not possible if the lines are combined into a block. This is sometimes the case when a satellite loss of lock occurs during a flight and the GPS solution fixes on the wrong integer ambiguity.
- Adjusted any small residual error (due to system noise) between flight lines and across all flight lines to survey ground control (or existing mapping if available).
- Clipped the outer edges of the swath to remove less accurate points.
- Adjust for vertical offsets.
- If all flights are consistent within the mapping specifications, cross flights and ground control data is imported and studied for fit. As a QA/QC measure, Woolpert has developed a routine to generate accuracy statistical reports by comparison among LiDAR points, ground control, and TINs generated by LiDAR points. The absolute accuracy is determined by comparison with ground control. Statistical analysis is then performed on the fit between the LiDAR data and the

ground control. Based on the statistical analysis, the LiDAR data is then adjusted in relation to the ground control.

- All final delivery data was determined to meet and or exceed the project specifications.
- The LiDAR LAS files have been classified into the following classifications:
    - Class 1 - Processed, but unclassified
    - Class 2 - Bare-earth ground
    - Class 7 - Noise

- At the completion of the hydrographic flattening process, the LiDAR data will be further classified to include:
    - Class 9 - Water
    - Class 10 - Ignored ground (breakline proximity)

SECTION 6: DATA ANALYSIS

Accuracy Assessment

The vertical accuracy statistics were calculated by evaluating the LiDAR bare earth to the ground control quality check points. Comparisons were also made between the checkpoints and the LiDAR derived terrain surface. The ground control survey data was collected in accordance with the FEMA "Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A". This data analysis was accomplished by comparing the ground control quality check points with the edited LiDAR points.

In bare earth areas, the Fundamental Vertical Accuracy (FVA) of the TIN for Project Area One (Sharkey) was required to meet a vertical accuracy of 30 cm at a 95% confidence level, based on NSSDA RMSE of 15 cm or better; using assessment procedures that comply with FEMA guidelines.

In bare earth areas, the Fundamental Vertical Accuracy (FVA) of the TIN for Project Area Two (Cane Creek) was required to meet a vertical accuracy of 18.5 cm at a 95% confidence level, based on NSSDA RMSE of 9.25 cm or better; using assessment procedures that comply with FEMA guidelines.

The FVA was calculated based on the analysis of ground control quality check points with the edited LiDAR points in the "open terrain" (bare earth) land cover category.

Fundamental Vertical Accuracy of the TIN for Project Area One (Sharkey) tested at 24.6 cm vertical accuracy at 95% percent confidence level. The RMSE for Project Area One (Sharkey) tested at 12.6 cm.

Table 6.1: Fundamental Vertical Accuracy Statistics for Area One

Bare Earth and Low Grass (meter)	
Root mean square	0.126
Minimum Error	0.010
Maximum Error	0.280
Average Error	0.105
Count	25

Fundamental Vertical Accuracy of the TIN for Project Area Two (Cane Creek) tested at 15.8 cm vertical accuracy at 95% percent confidence level. The RMSE for Project Area Two (Sharkey) tested at 8.1 cm.

Table 6.2 Fundamental Vertical Accuracy Statistics for Area Two

Bare Earth and Low Grass (meter)	
Root mean square	0.081
Minimum Error	0.010
Maximum Error	0.170
Average Error	0.066
Count	13

The Consolidated Vertical Accuracy (CVA) of the TIN for Project Area One (Sharkey) was required to meet a vertical accuracy of 30 cm at a 95% confidence level, according to ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, i.e. based on the 95th percentile error in all land cover categories combined.

The Consolidated Vertical Accuracy (CVA) of the TIN for Project Area One (Sharkey) was required to meet a vertical accuracy of 18.5 cm at a 95% confidence level, according to ASPRS Guidelines, Vertical Accuracy Reporting for LiDAR Data, i.e. based on the 95th percentile error in all land cover categories combined.

Consolidated Vertical Accuracy of the TIN for Project Area One (Sharkey) tested at 25.6 cm vertical accuracy at 95% percent confidence level. The RMSE for Project Area One (Sharkey) tested at 13.1 cm.

Table 6.3: Consolidated Vertical Accuracy Statistics for Area One

All Land Classes (meter)	
Root mean square	0.131
Minimum Error	0.010
Maximum Error	0.310
Average Error	0.107
Count	39

Consolidated Vertical Accuracy of the TIN for Project Area Two (Cane Creek) tested at 17.3 cm vertical accuracy at 95% percent confidence level. The RMSE for Project Area One (Sharkey) tested at 8.8 cm.

Table 6.4: Consolidated Vertical Accuracy Statistics for Area Two

All Land Classes (meter)	
Root mean square	0.088
Minimum Error	0.010
Maximum Error	0.190
Average Error	0.071
Count	22

SECTION 7: HYDRO FLATTENING PROCESSING AND QUALITY CONTROL

Hydro Flattening of LiDAR Data

This task required the compilation of breaklines defining water bodies and streams. The breaklines were used to perform the hydrologic flattening of water bodies, and gradient hydrologic flattening of double line streams. Lakes, reservoirs and ponds, at a nominal minimum size of two (2) acres or greater, were compiled as closed polygons. The closed water bodies were collected at a constant elevation. Rivers and streams, at a nominal minimum width of 100-feet, were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation. The hydrologic flattening of the LiDAR data was performed for inclusion in the National Elevation Dataset (NED).

LiDAR Data Review and Processing

Woolpert utilized the following steps to hydrologically flatten the water bodies and for gradient hydrologic flattening of the double line streams within the existing LiDAR data.

1. Woolpert utilized an integrated LiDAR and photogrammetric mapping approach for this task order. Coined “LiDARgrammetry”, this process integrates LiDAR surface model data with the intensity values to produce stereo models. This 3D LiDAR stereo model was viewed in stereo at a digital softcopy photogrammetric work station. Once this stereo 3D view is achieved, the photogrammetric technicians collect the 3D breaklines in a manner similar to conventional softcopy photogrammetric workflows.

2. Lakes, reservoirs and ponds, at a nominal minimum size of two (2) acres or greater, were compiled as closed polygons. The breaklines that defined the closed water bodies maintained a constant elevation. During the LiDAR data review, the technical staff used a program that displayed the polygon measurement area as a reference to identify lakes larger than two (2) acres. If the lake was larger than two (2) acres in width and/or length, the lake was defined with a breakline to be hydrologically flattened.

3. The breaklines defining rivers, creeks, and streams, at a nominal minimum width of 100-feet, were compiled in the direction of flow with both sides of the stream maintaining an equal gradient elevation. The image to the right, illustrates a good example of rivers at a nominal

minimum width of at least 100-feet, compiled in the direction of flow with both sides of the river maintaining an equal gradient elevation.

4. All DEM points were reclassified from inside the hydrologic feature polygons.

5. All DEM points were reclassified from within a five (5) foot buffer along the hydrologic feature breaklines.

6. The LiDAR mass points and hydrologic feature breaklines were used to generate a new digital elevation model.

7. The new hydrologically flattened DEM was delivered in ArcGRID format.

The horizontal datum used for the project was referenced to UTM Coordinate System, Zone 16, and North American Datum of 1983, 2007 Datum. Coordinate positions were specified in units of meters. The vertical datum used for the project was referenced to NAVD 1988, Geoid03, in meters.

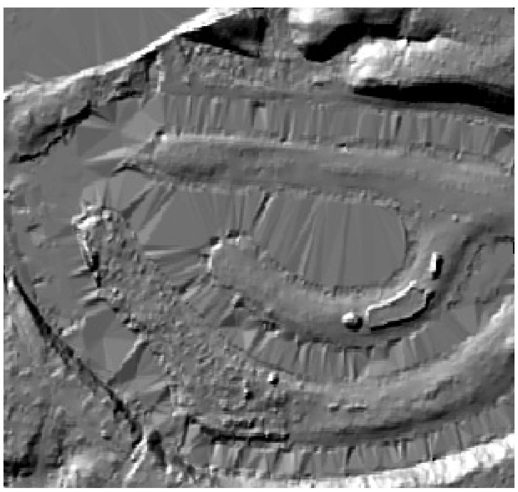


Figure 1

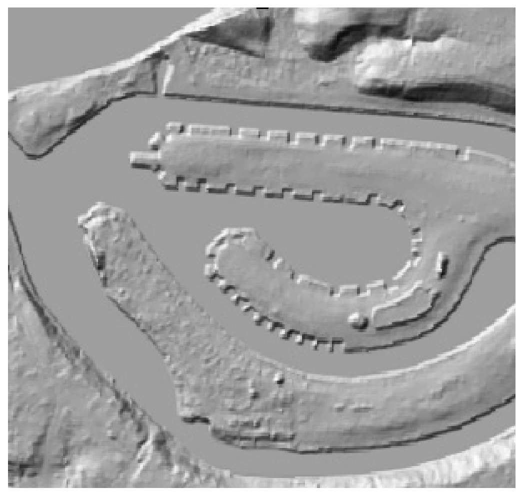


Figure 2

Figure 1 reflects a DEM generated from an original LiDAR bare earth point data prior to the hydrologic flattening process. Note the “tinning” across the water.

Figure 2 reflects a DEM generated from LiDAR with breaklines compiled to define the hydrologic features. This figure illustrates the results of adding the breaklines to hydrologically flatten the DEM data. Note the smooth appearance of the water in the DEM.

The hydrologically flattened DEM data was provided to USGS in ArcGRID format at a 1-meter posting, in 1,000 x 1,000 meter tiles.

Terrascan was used to add the hydrologic breakline vertices and export lattice models.

A batch script was developed to process the blocks of ArcGRIDs. A representation of a batch script is listed below:

Asciitoraster_conversion <path of input file in .asc format> <path of output file in GRID format> float

A batch file resembled the script below when finished:

```
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE350530.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE350530 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE350540.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE350540 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE350550.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE350550 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE350560.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE350560 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE360520.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE360520 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE360530.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE360530 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE360540.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE360540 float
Asciitoraster_conversion I:\PH\70452_Arkansas_Tenn_USGS\Carto\Lattice_TN_NEW1\TN16SBE360550.asc I:\PH\70452_Arkansas_Tenn_USGS\Carto\GRIDS_TN_NEW1\TN16SBE360550 float
```

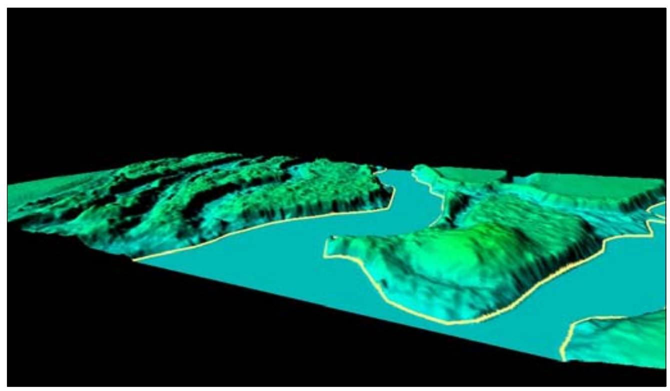
In ArcCatalog, the command line window was used. The entire batch file was copied and pasted into the command line window. The batch file was processed, creating the ArcGRID DEM files.

The hydrologic breaklines compiled as part of the flattening process were provided to the USGS as a shapefile deliverable. The breaklines defining the water bodies greater than two (2) acres in each block were provided as a Polygon Z file. The breaklines compiled for the gradient flattening of all rivers, creeks and streams at a nominal minimum width of 100-feet in each block were provided as a Polyline Z file.

Woolpert tested and refined our processes during production. Woolpert found that this process would yield virtually error-free results in a very efficient manner.

Data QA/QC

QA/QC for this task order was performed in Global Mapper, by reviewing the grids and hydrologic breakline features.



Edits and corrections found during the QA/QC process were addressed individually by tile. If a water body breakline needed to be lowered or adjusted to improve the flattening of the ArcGRID DEM, the area was cross referenced to the tile number, fixed, regenerated by individual tile and reviewed in GlobalMapper.

Final Deliverables

- One set of hydrologically flattened LiDAR data bare earth 1,000 x 1,000 meter tiles in ArcGRID format.
- LAS v1.2 classified point cloud and bare earth point files in tile format.
- LAS v1.2 raw unclassified flightline strips no greater than 2GB.
- Intensity Images as tiles in ArcGRID FLOAT format.
- Breaklines compiled as part of the hydrologic flattening process were provided as ESRI Polyline Z or PolygonZ shape files.
- FGDC compliant metadata by file in XML format.
- The project data was delivered on external USB 2.0 hard drives.

The DEMs produced under this task order met the following specifications:

- The water body hydrologic flattening and gradient hydrologic flattening of double line streams was completed using the methodology described in this report and Woolpert's original proposal in response to the task order.
- The DEMs were edge joined.
- All characters in the DEM header are in upper case.
- The hydrologically flattened bare earth data was delivered in ArcGRID FLOAT format at a 1-meter posting.