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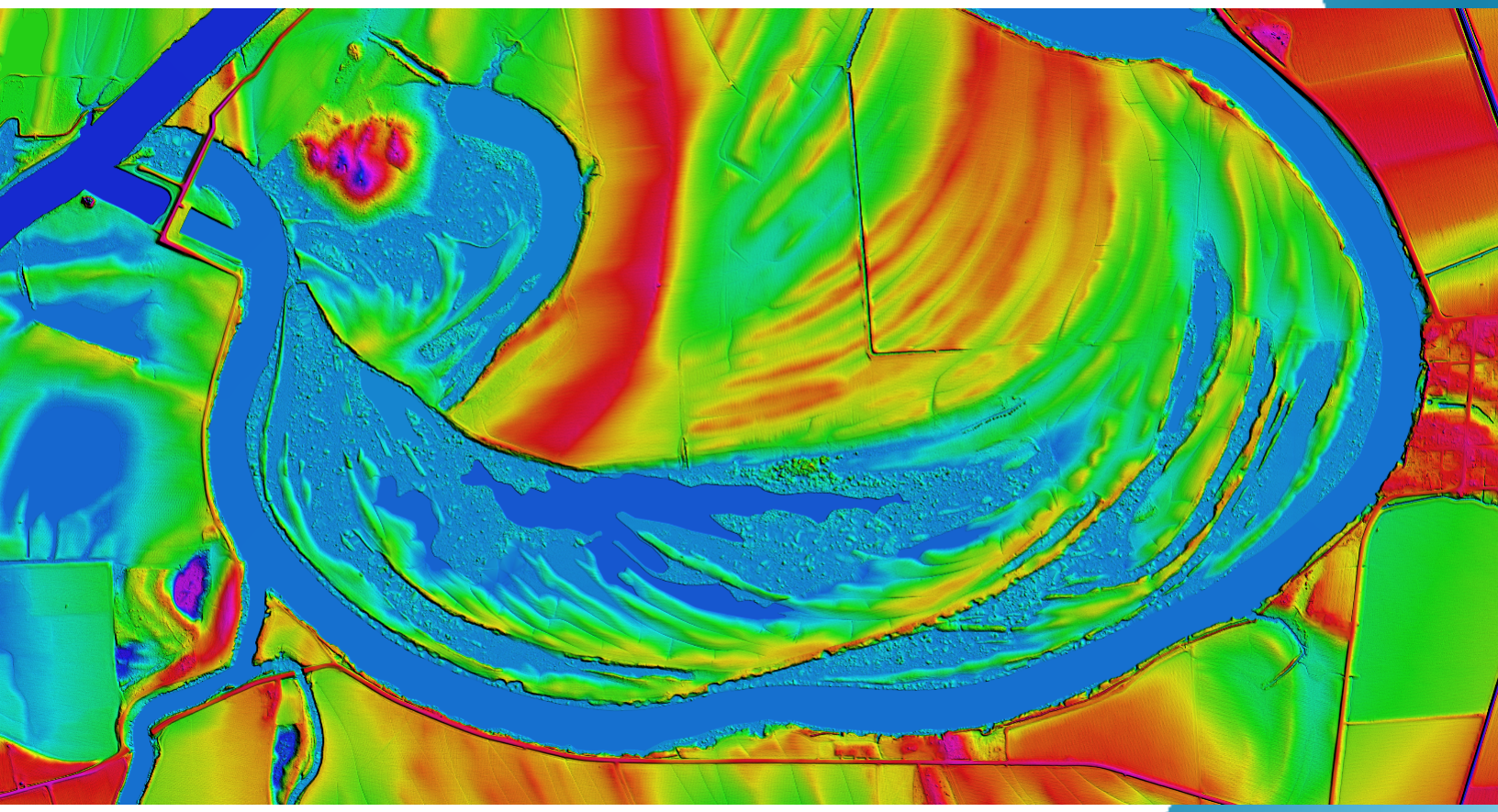

MS_MISSISSIPPIDELTA_2018_D18 LIDAR PROCESSING REPORT

2021

Project ID: 78034
Work Unit: 222316

Submitted: September 7, 2021

Prepared for:

USGS
science for a changing world

Prepared by:

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523 Wellington Way, Suite 225
Lexington, KY 40503

859.277.8700

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1. Summary / Scope

1.1. Summary

This report contains a summary of the MS_MississippiDelta_2018_D18 lidar acquisition task order, issued by USGS under their Contract G16PC00016 on February 27, 2018. Work Unit 222316 yielded a project area covering approximately 2,733 square miles over Mississippi. The intent of this document is only to provide specific validation information for the data acquisition/ collection, processing, and production of deliverables completed as specified in the task order.

1.2. Scope

Aerial topographic LiDAR was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned LiDAR Specifications

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
2 pts / m^2	2000-2200 m	36°-60°*	20%	≤ 10 cm

*FOV is dependent upon sensor utilized. See Table 2 for more info

1.3. Coverage

The project boundary covers approximately 2,733 square miles over Mississippi. A buffer of 100 meters was created to meet task order specifications. Project extents are shown in Figure 1.

1.4. Duration

LiDAR data was acquired from February 26, 2018 to December 13, 2020 in 30 total lifts. See “Section: 2.4. Time Period” for more details.

1.5. Issues

Due to different flying seasons, several temporal differences occur throughout the dataset.

MS_MississippiDelta_2018_D18 Work Unit 222316 Projected Coordinate System: Albers Horizontal Datum: NAD 1983(2011) Vertical Datum: NAVD88 (GEOID 12b) Units: Meters	
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	• 1-meter Hydro-flattened Bare Earth Digital Elevation Model (DEM) in IMG format • 1-meter Intensity images in GeoTIFF format
Vectors	Shapefiles (*.shp) • Project Boundary • LiDAR Tile Index Geodatabase (*.gdb) • Continuous Hydro-flattened Breaklines
Reports	Reports in PDF format • Focus on Delivery • Processing Report
Metadata	XML Files (*.xml) • Breaklines • Classified Point Cloud • DEM • Intensity Imagery

MS_MississippiDelta_2018_D18
Work Unit 222316 Boundary

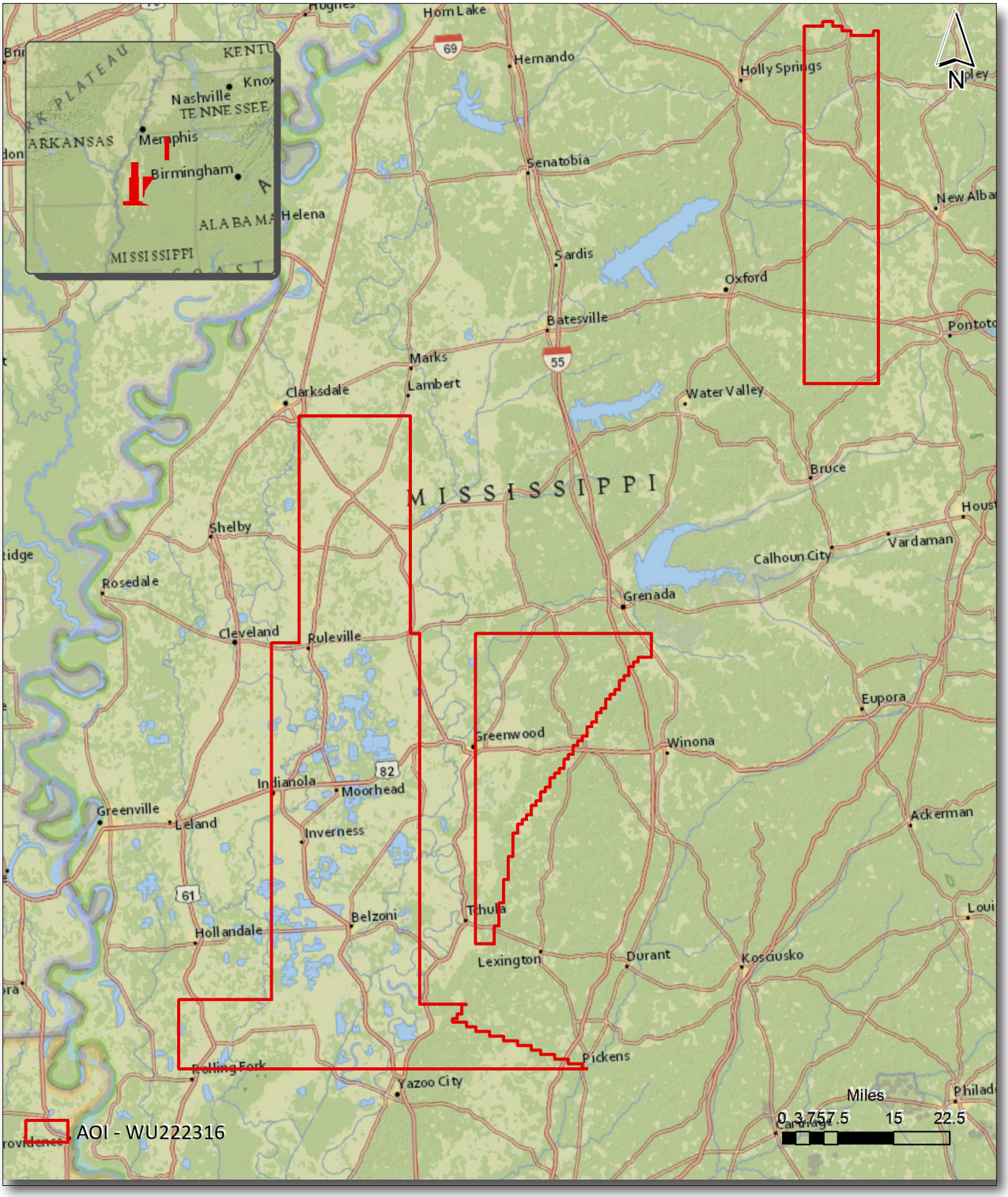

Figure 1. Work Unit Boundary

2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using Leica MissionPro and RiPARAMETER planning software. Planned flight lines are shown in Figure 2.

2.2. Lidar Sensor

NV5 Geospatial utilized Leica ALS70, Leica ALS80, Riegl VQ1560i/VQ1560ii LiDAR sensors (Figure 3) for lidar acquisition.

The Leica ALS 70 system is capable of collecting data at a maximum frequency of 500 kHz, which affords elevation data collection of up to 500,000 points per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd and last returns. The intensity of the returns is also captured during aerial acquisition.

The Leica ALS 80 system is capable of collecting data at a maximum frequency of 1,000 kHz. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor also has the capacity for unlimited range returns from each outbound pulse. The intensity of the returns is also captured during aerial acquisition.

The Riegl 1560i system has a laser pulse repetition rate of up to 2 MHz resulting in more than 1.3 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to an unlimited number of targets per pulse from the laser.

The Riegl 1560II system is a dual channel waveform processing airborne scanning system. It has a laser pulse repetition rate of up to 4 MHz resulting in up to 2.66 million measurements per second. The system utilizes a Multi-Pulse in the Air option (MPIA) and an integrated IMU/GNSS unit.

A brief summary of the aerial acquisition parameters for the project are shown in the LiDAR System Specifications in Table 2.

MS_MississippiDelta_2018_D18
Work Unit 222316 Planned Flight Lines

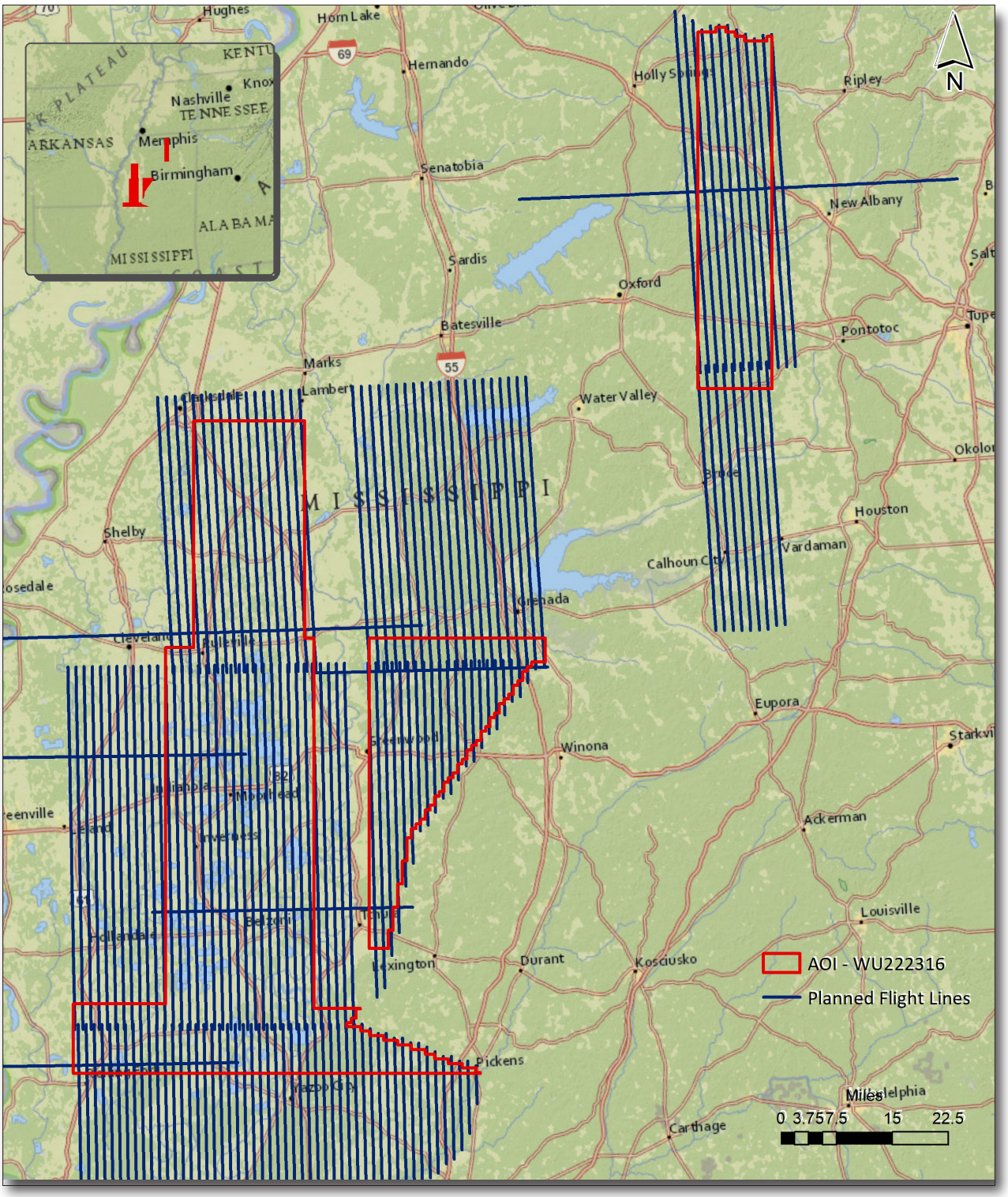

Figure 2. Planned Flight Lines

Table 2. LiDAR System Specifications

		Leica ALS70	Leica ALS80	Riegl VQ1560i/ Riegl VQ1560ii
Terrain and Aircraft Scanner	Flying Height	2000 m	2200 m	2000 m
	Recommended Ground Speed	150 kts	150 kts	160 kts
Scanner	Field of View	36°	40°	60°
	Scan Rate Setting Used	56 Hz	49 Hz	129 Hz
Laser	Laser Pulse Rate Used	278 kHz	372.8 kHz	700 kHz
	Multi Pulse in Air Mode	yes	yes	yes
Coverage	Full Swath Width	1300 m	1601 m	2309 m
	Line Spacing	1040 m	1120.7 m	1847.2 m
Point Spacing and Density	Average Point Spacing	0.6 m	0.6 m	0.7 m
	Average Point Density	2.78 pts / m^2	2.78 pts / m^2	2.04 pts / m^2

Figure 3. Leica ALS70, Leica ALS80, and Riegl VQ1560i/VQ1560ii Lidar Sensors

2.3. Aircraft

All flights for the project were accomplished through the use of customized planes. Plane type and tail numbers are listed below.

LiDAR Collection Planes

- Piper Navajo (twin-piston), Tail Numbers: N262AS, N73TM, C-FFRY, N6GR, C-GJMT, C-GMEC
- Cessna Caravan (single-turboprop), Tail Number: N704MD

These aircraft provided an ideal, stable aerial base for lidar acquisition. These aerial platforms have relatively fast cruise speeds, which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds, proving ideal for collection of high-density, consistent data posting using a state-of-the-art lidar systems. Some of Quantum Spatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of NV5 Geospatial's Planes

2.4. Time Period

Project specific flights were conducted between February 18, 2018 and December 13, 2020. Thirty aircraft lifts were completed. Accomplished lifts are listed below.

- 02262018A (SN8227,N6GR)
- 01102019B (SN7161,N262AS)
- 01162019A (SN7161,N262AS)
- 01242019A (SN043-AI,C-FFRY)
- 01252019A (SN043-AI,C-FFRY)
- 01252019A (SN7161,N262AS)
- 01272019A (SN546,N73TM)
- 01272019A (SN7161,N262AS)
- 01282019A (SN546,N73TM)
- 01282019A (SN7161,N262AS)
- 01292019A (SN043-AI,C-FFRY)
- 01302019A (SN043-AI,C-FFRY)
- 01302019A (SN546,N73TM)
- 01302019B (SN546,N73TM)
- 01312019A (SN043-AI,C-FFRY)
- 01312019A (SN546,N73TM)
- 01312019B (SN546,N73TM)
- 02022019A (SN546,N73TM)
- 02082019A (SN043-AI,C-FFRY)
- 02092019A (SN043-AI,C-FFRY)
- 02242019A (SN043-AI,C-FFRY)
- 02292019A (SN043-AI,C-FFRY)
- 12062020A (SN4040,N704MD)
- 12072020A (SN2737,C-GJMT)
- 12082020A (SN2737,C-GJMT)
- 12092020A (SN2737,C-GJMT)
- 12092020A (SN3062,C-GMEC)
- 12092020A (SN4040,N704MD)
- 12102020A (SN2737,C-GJMT)
- 12132020A (SN3062,C-GMEC)

3. Processing Summary

3.1. Flight Logs

Flight logs were completed by LIDAR sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc).

3.2. LiDAR Processing

Applanix + POSPac and Leica Inertial Explorer software were used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the LiDAR sensor during all flights. Applanix POSPac combines aircraft raw trajectory data with stationary GPS base station data yielding a "Smoothed Best Estimate Trajectory" (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Applanix POSPac and Inertial Explorer processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

Point clouds were created using RiPROCESS and Leica CloudPro software. The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. The point cloud is imported into GeoCue distributive processing software. Imported data is tiled and then calibrated using TerraMatch and proprietary software. Using TerraScan, the vertical accuracy of the surveyed ground control is tested and any bias is removed from the data. TerraScan and TerraModeler software packages are then used for automated data classification and manual cleanup. The data are manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler.

DEMs and Intensity Images are then generated using proprietary software. In the bare earth surface model, above-ground features are excluded from the data set. Global Mapper is used as a final check of the bare earth dataset.

Finally, proprietary software is used to perform statistical analysis of the LAS files.

Software	Version
Leica Inertial Explorer	8.90
Leica CloudPro	1.2.4
RiPROCESS	1.8.6
Applanix + POSPac	8.4
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
TerraModeler	21.008
TerraScan	21.0016
TerraMatch	21.007

3.3. LAS Classification Scheme

The classification classes are determined by the USGS Version 1.3 specifications and are an industry standard for the classification of LIDAR point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

Table 3. LAS Classifications

	Classification Name	Description
1	Processed, but Unclassified	Laser returns that are not included in the ground class, or any other project classification
2	Bare earth	Laser returns that are determined to be ground using automated and manual cleaning algorithms
7	Low Noise	Laser returns that are often associated with scaterring from reflective surfaces, or artificial points below the ground surface
9	Water	Laser returns that are found inside of hydro features
10	Ignored Ground	Ground points that fall within the given threshold of a collected hydro feature.
17	Bridge Deck	Laser returns falling on bridge decks
18	High Noise	Laser returns that are often associated with birds or artificial points above the ground surface
22	Temporal Exclusion	Points that are excluded due to differences in collection dates

3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare- earth surface is finalized; it is then used to generate all hydro-breaklines through heads-up digitization.

All ground (ASPRS Class 2) LiDAR data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using proprietary tools. A buffer of 1 meter was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 10). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 2) points were reclassified to the correct classification after the automated classification was completed.

Any noise that was identified either through manual review or automated routines was classified to the appropriate class (ASPRS Class 7 and/or ASPRS Class 18) followed by flagging with the withheld bit.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for all point cloud data. Quantum Spatial's proprietary software was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

3.5. Hydro-Flattened Breakline Processing

Class 2 LiDAR was used to create a bare earth surface model. The surface model was then used to heads-up digitize 2D breaklines of Inland Streams and Rivers with a 100 foot nominal width and Inland Ponds and Lakes of 2 acres or greater surface area.

Elevation values were assigned to all Inland streams and rivers using Quantum Spatial's proprietary software.

All ground (ASPRS Class 2) LiDAR data inside of the collected inland breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 3 feet was also used around each hydro flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 10).

The breakline files were then translated to Esri file geodatabase format using Esri conversion tools.

Breaklines are reviewed against lidar intensity imagery to verify completeness of capture. All breaklines are then compared to TINs (triangular irregular networks) created from ground only points prior to water classification. The horizontal placement of breaklines is compared to terrain features and the breakline elevations are compared to lidar elevations to ensure all breaklines match the lidar within acceptable tolerances. Some deviation is expected between breakline and lidar elevations due to monotonicity, connectivity, and flattening rules that are enforced on the breaklines. Once completeness, horizontal placement, and vertical variance is reviewed, all breaklines are reviewed for topological consistency and data integrity using a combination of Esri Data Reviewer tools and proprietary tools.

3.6. Hydro-Flattened Raster DEM Processing

Class 2 LiDAR in conjunction with the hydro breaklines were used to create a 1-meter raster DEM. Using automated scripting routines within proprietary software, an IMG file was created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.7. Intensity Image Processing

GeoCue software was used to create the deliverable intensity images. All withheld points were ignored during this process. This helps to ensure a more aesthetically pleasing image. The

GeoCue software was then used to verify full project coverage as well. GeoTIFF files with a cell size of 1-meter were then provided as the deliverable for this dataset requirement.

MS_MississippiDelta_2018_D18
Work Unit 222316 Tile Layout

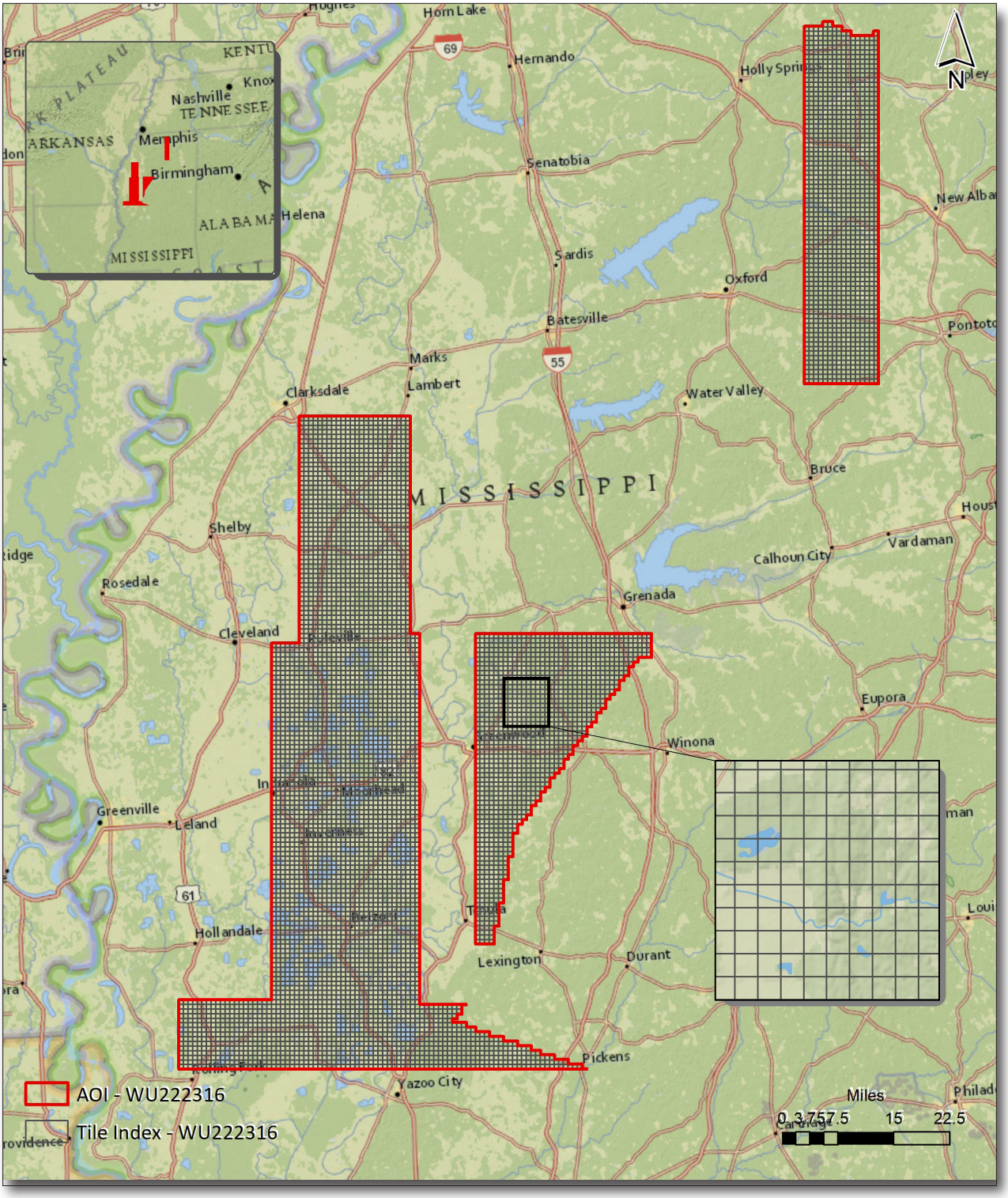

Figure 5. Lidar Tile Layout

4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 6.

MS_MississippiDelta_2018_D18
Work Unit 222316 Lidar Coverage

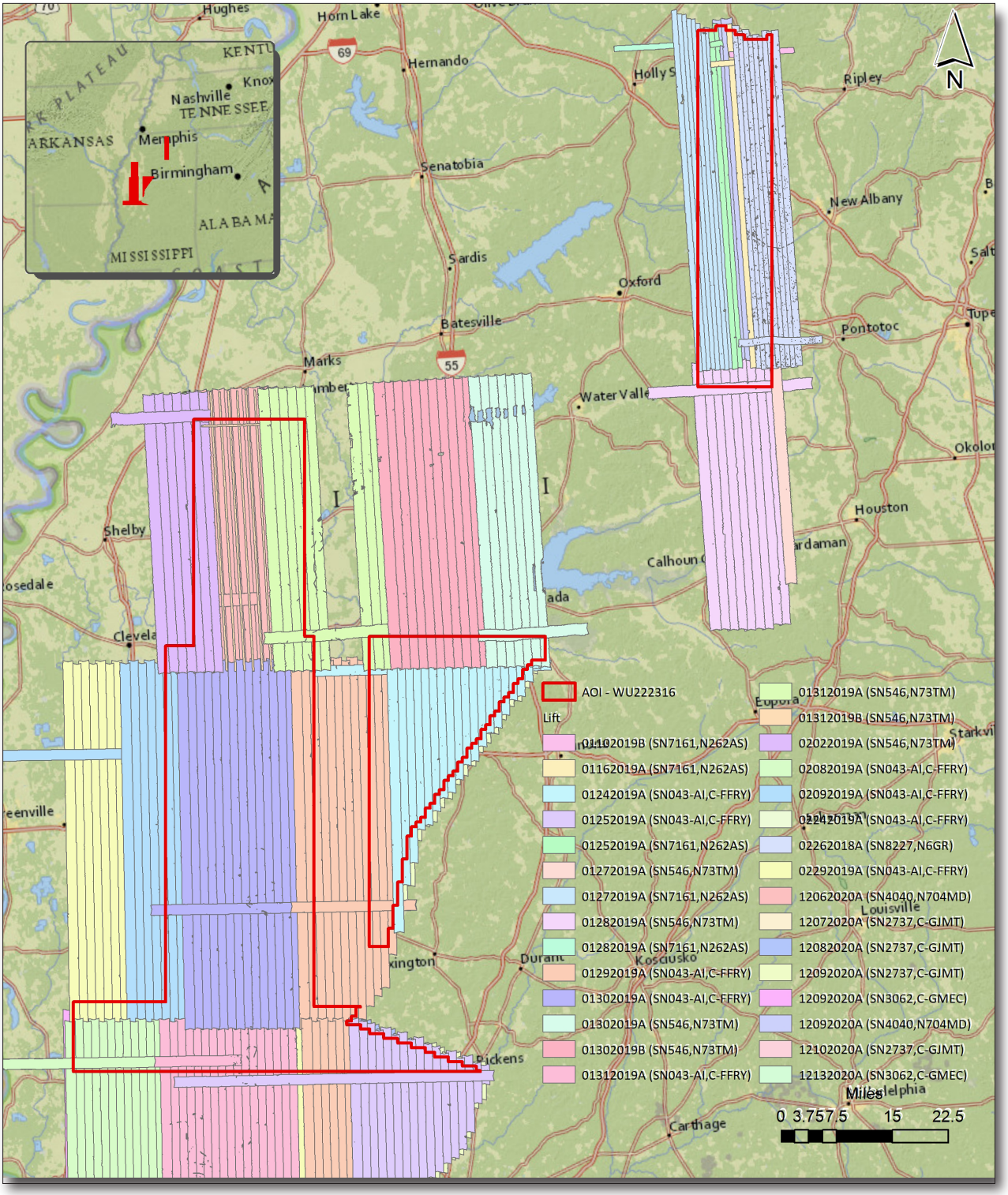

Figure 6. Lidar Coverage

Project Report Appendices

The following section contains the appendices as listed in the MS_MississippiDelta_2018_D18 Lidar Processing Report.

Appendix A

Flight Logs

Julian Day 342	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 7, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Mississippi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T-2C
H-100%
AMLS-106
Hpa-1019

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:38	**Takeoff**	14:54	
Engine Off	18:21	**Landing**	18:06	
Total	3.7 hrs	**Total**	3.2 hrs	

Mission Plan				
AGL Height	2000 m	**Pulse Rate**	700khz	
Target Speed	160 kts	**Scan Rate**	182hz	
Laser Current	100 %	**FOV**	60 degs	

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1445	1450
Post Mission	1810	1815

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
F8		-	1504	1509				
X-tie	372034201	-	1514	1525			151424	
4025	372034202	002	1531	1550			153136	
4026	372034203	183	1552	1605			155228	
4027	372034204	002	1610	1626			161052	
4028	372034205	183	1629	1643			162945	
4029	372034206	002	1646	1701			164638	
4030	372034207	183	1704	1716			170408	
4031	372034208	002	1719	1734			171942	
4032	372034209	183	1737	1750			173715	
F8		-	1751	1756				

Julian Day	343	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 8, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Misisipi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

PostView not connecting need to restart 2 times.
T-3C
H-100%

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:36	**Takeoff**	15:06	
Engine Off	21:46	**Landing**	21:33	
Total	7.2 hrs	**Total**	6.5 hrs	

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700khz	
Target Speed	160	kts	**Scan Rate**	320hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1455	1500
Post Mission	2136	2141

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
F8		-	1523	1528				
X-tie	372034301	-	1529	1536			152933	
4033	372034302	002	1540	1552			154017	
4034	372034303	183	1556	1607			155633	
4035	372034304	002	1611	1624			161130	
4036	372034305	183	1628	1639			162822	
4037	372034306	002	1644	1658			164405	
4038	372034307	183	1701	1713			170121	
4039	372034308	002	1717	1729			171723	
4040	372034309	183	1734	1745			173423	
4041	372034310	002	1750	1803			175057	
4042	372034311	183	1807	1818			180735	
4043	372034312	002	1824	1835			182402	
4044	372034313	183	1839	1849			183953	
4045	372034314	002	1855	1905			185538	

Julian Day 343	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 8, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Misisipi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

PostView not connecting need to restart 2 times.
T-3C
H-100%

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:36	**Takeoff**	15:06	
Engine Off	21:46	**Landing**	21:33	
Total	7.2 hrs	**Total**	6.5 hrs	

Mission Plan			
AGL Height	2000 m	**Pulse Rate**	700khz
Target Speed	160 kts	**Scan Rate**	320hz
Laser Current	100 %	**FOV**	60 degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1455	1500
Post Mission	2136	2141

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
4047	372034315	183	1910	1911			191016	
X-tie	372034316	-	1913	1915			191342	
4046	372034317	183	1922	1931			192228	
6001	372034318	002	1937	1945			193733	
6002	372034319	183	1950	1957			195014	
6003	372034320	002	2002	2010			200258	
6004	372034321	183	2015	2021			201505	
6005	372034322	002	2026	2033			202633	
6006	372034323	183	2038	2044			203812	
6007	372034324	002	2049	2055			204930	
6008	372034325	183	2100	2106			210028	
X-tie	372034326	-	2110	2114			211046	
F8			2114	2119				

Julian Day	343	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 8, 2020	**Aircraft**	C-GMEC
Project	3210 QSI Mississippi	**Pilot**	Y. Kadota
Location	Jackson, MS	**Operator**	B. Eisenbart
Mission Objective			

System	1560i
Unit	S2223062
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time					
Engine On	15:21	**Takeoff**	15:35		
Engine Off	21:39	**Landing**	21:30		
Total	6.3 hrs	**Total**	5.9 hrs		

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700 kHz	
Target Speed	160	kts	**Scan Rate**	182 hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	15:25	15:30
Post Mission	21:32	21:37

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 201208	Comments
			Start	End	Time	nmi to End		
PPP-8	-	-	15:59	16:04			-	Figure 8
1015	622034301	003°	16:09	16:26			160911	
1016	622034302	183°	16:30	16:34			163006	snapshot crashed, stopped scanning
1016	622034303	183°	16:45	17:00			164527	reflew line
1017	622034304	003°	17:04	17:22			170437	
1018	622034305	183°	17:25	17:40			172505	
1019	622034306	003°	17:44	18:01			174411	
1020	622034307	183°	18:04	18:05			180444	
1021	622034308	003°	18:09	18:11			180932	
2002	622034309	183°	18:15	18:16			181510	
2001	622034310	003°	18:19	18:21			181933	
X-TIE1015-19	622034311	273°	18:24	18:28			182411	
X-TIE 4001-10	622034312	269°	18:41	18:48			184115	
4001	622034313	003°	18:52	18:55			185225	
4002	622034314	273°	18:58	19:00			185817	

Julian Day	343	Flight	A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 8, 2020	**Aircraft**	C-GMEC
Project	3210 QSI Mississippi	**Pilot**	Y. Kadota
Location	Jackson, MS	**Operator**	B. Eisenbart
Mission Objective			

System	1560i
Unit	S2223062
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	15:21	**Takeoff**	15:35	
Engine Off	21:39	**Landing**	21:30	
Total	6.3 hrs	**Total**	5.9 hrs	

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700 kHz	
Target Speed	160	kts	**Scan Rate**	182 hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	15:25	15:30
Post Mission	21:32	21:37

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 201208	Comments
			Start	End	Time	nmi to End		
4003	622034315	003°	19:04	19:08			190430	
4004	622034316	183°	19:11	19:22			191150	
4005	622034317	003°	19:25	19:37			192550	
4006	622034318	183°	19:40	19:51			194038	
4007	622034319	003°	20:01	20:16			200142	
4008	622034320	183°	20:19	20:33			201939	
4009	622034321	003°	20:36	20:52			203656	
4010	622034322	183°	20:55	21:09			205535	
PPP-8		-	21:10	21:16			-	Figure 8

Julian Day 344	Flight A

LIDAR Flight Log

AIRBORNE IMAGING
A Clean Harbors Company

Date	December 9, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Misisipi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T-1C
H-86%
AMLS-106m
Hpa-1022

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:11	**Takeoff**	14:35	
Engine Off	20:52	**Landing**	20:41	
Total	6.7 hrs	**Total**	6.1 hrs	

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700khz	
Target Speed	160	kts	**Scan Rate**	320hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1423	1428
Post Mission	2044	2049

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
F8		-	1444	1449				
6009	372034401	003	1452	1459			145245	
5001	372034402	003	1506	1515			150608	
X-tie	372034403	-	1522	1528			152215	
5019	372034404	183	1533	1534			153342	
5018	372034405	003	1538	1539			153806	
5017	372034406	183	1543	1545			154304	
5016	372034407	003	1547	1549			154757	
5015	372034408	183	1553	1555			155315	
5014	372034409	003	1559	1602			155920	
5013	372034410	183	1605	1609			160548	
5012	372034411	003	1612	1617			161243	
5011	372034412	183	1619	1624			161953	
5010	372034413	003	1627	1632			162743	
5009	372034414	183	1636	1641			163602	

Julian Day 344	Flight A

LIDAR Flight Log

Date	December 9, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Misisipi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T-1C
H-86%
AMLS-106m
Hpa-1022

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:11	**Takeoff**	14:35	
Engine Off	20:52	**Landing**	20:41	
Total	6.7 hrs	**Total**	6.1 hrs	

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700khz	
Target Speed	160	kts	**Scan Rate**	320hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1423	1428
Post Mission	2044	2049

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
5008	372034415	003	1645	1651			164503	
5007	372034416	183	1654	1701			165438	
5006	372034417	003	1704	1712			170445	
5005	372034418	183	1715	1722			171550	
5004	372034419	003	1726	1734			172636	
5003	372034420	183	1737	1747			173758	
5002	372034421	003	1751	1802			175149	
3015	372034422	183	1810	1825			181001	
3014	372034423	003	1829	1845			182902	
3013	372034424	183	1848	1903			182822	
X-tie	372034425	-	1907	1909			190717	
6010	372034426	183	1915	1920			191506	
6011	372034427	003	1924	1929			192402	
6012	372034428	183	1933	1938			193314	
6013	372034429	003	1942	1946			194234	

Julian Day	344	Flight	A

LIDAR Flight Log

Date	December 9, 2020	**Aircraft**	C-GJMT
Project	3210_QSI_Misisipi	**Pilot**	J.Mathieson
Location	Jackson MS	**Operator**	D.Arteaga
Mission Objective			

System	Riegl VQ-1560i
Unit	37
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

T-1C
H-86%
AMLS-106m
Hpa-1022

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time				
Engine On	14:11	**Takeoff**	14:35	
Engine Off	20:52	**Landing**	20:41	
Total	6.7 hrs	**Total**	6.1 hrs	

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700khz	
Target Speed	160	kts	**Scan Rate**	320hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	1423	1428
Post Mission	2044	2049

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID	Comments
			Start	End	Time	nmi to End	Time Stamp _____	
6014	372034430	183	1950	1954			195030	
6015	372034431	003	1959	2002			195914	
6016	372034432	183	2006	2007			200605	
6017	372034433	003	2012	2013			201202	
X-Tie	372034434	-	2017	2021			201723	
F8		-	2021	2026				

Julian Day	348	Flight	A

LIDAR Flight Log

Date	December 13, 2020	**Aircraft**	C-GMEC
Project	3210 QSI Mississippi	**Pilot**	A. Lavalliere
Location	Jackson, MS	**Operator**	B. Eisenbart
Mission Objective			

System	1560i
Unit	S2223062
IMU	Applanix AP60
GPS Rx	Trimble GNSS17
Scanner 1 Drive	
Scanner 2 Drive	

Additional Notes

System required restart after startup

Time to next maintenance: _____ ◉ 50 hr ○ 100 hr

Aircraft Block Time					
Engine On	15:41	**Takeoff**	16:13		
Engine Off	18:15	**Landing**	18:05		
Total	2.6 hrs	**Total**	1.9 hrs		

Mission Plan					
AGL Height	2000	m	**Pulse Rate**	700 kHz	
Target Speed	160	kts	**Scan Rate**	182 hz	
Laser Current	100	%	**FOV**	60	degs

Static Alignment	GPS Time	
	Start	**End**
Pre Mission	15:59	16:04
Post Mission	18:08	18:13

Flight Line	LiDAR File Name	Flight Direction	GPS Time		Line Aborted		Mission ID Time Stamp 201213	Comments
			Start	End	Time	nmi to End		
PPP-8	-	-	16:27	16:32			-	Figure 8
4031	622034801	003°	16:34	16:46			163439	
4030	622034802	183°	16:49	17:03			164958	
4029		003°	17:07		17:15		170721	Flew through virga, line aborted
4032		183°	17:23		17:38		172327	clouds on the south end, line aborted
X-TIE		93°	17:42	17:45			174217	
PPP-8	-	-	17:45	17:49			-	Figure 8

Airborne LiDAR Data Collection Log Sheet :: Quantum Spatial, Inc

(email log daily to flight_log_distribution_list@quantumspatial.com)

Date: 12-06-2020

Lift: (A) B C D E Pg 1 of 1

Project: MS Delta Proj #: 32274 Flight Mgmt File: 20201206A Swan

Aircraft: 704MD Begin Hobbs: 15006.2 End Hobbs: 15011.9 Total: 5.7 Pilot: Baumgarten Co-Pilot: Tech: ~~Schoene~~

Dep Apt: OLV Dep Time (Lcl): 939 (Z): +6 Arr Apt: OLV Arr Time (Local): 1524 (Z): +6 Tot Time Aloft: 5.7

CORS: Y / N Sta 1: Sta 2: Flyovers: Y / N If Y, times: Sta1) Sta2)

GPS Unit: Y / N Sta 1: Sta 2: Flyovers: Y / N If Y, times: Sta1) Sta2)

Gd Temp beg: °c End: °c OAT beg: °c End: °c Altimeter begin: 145 end: 3001

LiDAR										
Type	1560 ii	Serial #	4040	Alt AGL	2195	Alt AMSL		Avg Terr Ht		Max Gdspd ~~160~~	Avg Pt Spacing
FOV		Scan Freq	831 ps	MpIA Y / N		Pulses In Air		Pulse Rate	350 kHz	Power 100%	PPSM 2

	Beg GB	Storage Name/#
	848	
	End GB	
	Tot GB	

Line #	Hdg	Start (UTC):	End (UTC):	Gd Spd	PDOP/# Sats	GPS Altitude	Crab	Turb (0, -, +)	FLIGHT LINE NOTES – visibility, clouds, smoke, partial, etc.
6009	181	1638	1640	131	1/33	7310			
6008	1	1643	1652	138	1/31	7296			
6007	181	1653	1703	125	1/28	7296			
6006	181	1706	1714	134	1/29	7286			
6005	181	1717	1726	120	1/28	7286			(A) Hobbs = 5.7
6004	1	1729	1737	135	1/27	7308			onLine = 4.2
6003	181	1744	1745	138	1/30	7295			mob = 1.5
6002	1	1749	1752	138	1/29	7342			
6001	181	1755	1757	144	1/29	7301			
6025	91	1801	1807	155	1/30	7290			Xtie planned
6016	1	1815	1830	147	1/29	7299			
6017	181	1832	1846	120	1/26	7299			
6018	1	1848	1903	149	1/25	7299			- [redacted] precip on last 2 Lines! 6026/6024
6019	181	1906	1920	120	1/24	7299			
6020	1	1923	1937	143	1/26	7299			
6021	181	1939	1953	140	1/24	7299			
6022	1	1956	2010	143	1/24	7322			
6023	181	2013	2027	144	1/24	7306			

Xtie planned	Dir	start	stop	speed	Alt	
6026 =	270	2033	2038	144	7299	Refly
6024 =	01	2045	Abort	130	7306	Refly

Total Proj Lines:	Lines Flown:	Lines Remain:	OnLine Time:	Mob Time:	Notes:

Airborne LiDAR Data Collection Log Sheet :: Quantum Spatial, Inc

(email log daily to flight_log_distribution_list@quantumspatial.com)

Date: 12-9-2020

Lift: (A) B C D E Pg 1 of 1

Project: MS Delta A0/QSI Proj #: 32274 Flight Mgmt File: 20201209_SN4040_AR032274 swan

Aircraft: 704MD Begin Hobbs: 15020.3 End Hobbs: ~~1052~~ Total: 2.8 Pilot: Baumgarten Co-Pilot: Tech: ~~Schoone~~

Dep Apt: OLV Dep Time (Lcl): 925 (Z): +6 15023.1 Arr Apt: OLV Arr Time (Local): (Z): +6 Tot Time Aloft: 2.8

CORS: Y / N Sta 1: Sta 2: Flyovers: Y / N If Y, times: Sta1) Sta2)

GPS Unit: Y / N Sta 1: Sta 2: Flyovers: Y / N If Y, times: Sta1) Sta2)

Gd Temp beg: °c End: °c OAT beg: °c End: °c Altimeter begin: end:

LIDAR	Type 1560i	Serial # 4040	Alt AGL	Alt AMSL	Avg Terr Ht	Max Gdspd 160	Avg Pt Spacing
	FOV	Scan Freq 83 lps	MpiA Y / N	Pulses In Air	Pulse Rate 350kHz	Power 100%	PPSM 2

	Beg GB	Storage Name/#
	End GB	
	Tot GB	

	Line #	Hdg	Start (UTC):	End (UTC):	Gd Spd	PDOP/# Sats	GPS Altitude	Crab	Turb (0,-,+)	FLIGHT LINE NOTES – visibility, clouds, smoke, partial, etc.
A0	6024	181	1602	1616	145	1/29	7300			Reflight good
	6026	271	1623	1628	120	1/32	7323			Reflight good
	6023	1	1636	1652	126	1/31	7293			Reflight good * A0 site complete *
	QSI site									
5023	5023	92	1712	1713	160	1/31	7460			planned xtie
5021	5021	2	1718	1736	145	1/30	7391			5021
5020	5020	182	1738	1756	145	1/29	7391			* QSI site Complete *
										(A) Hobbs = 2.8
										on line = 1.9
										mob = 0.9

Total Proj Lines:	Lines Flown:	Lines Remain:	OnLine Time:	Mob Time:	Notes: