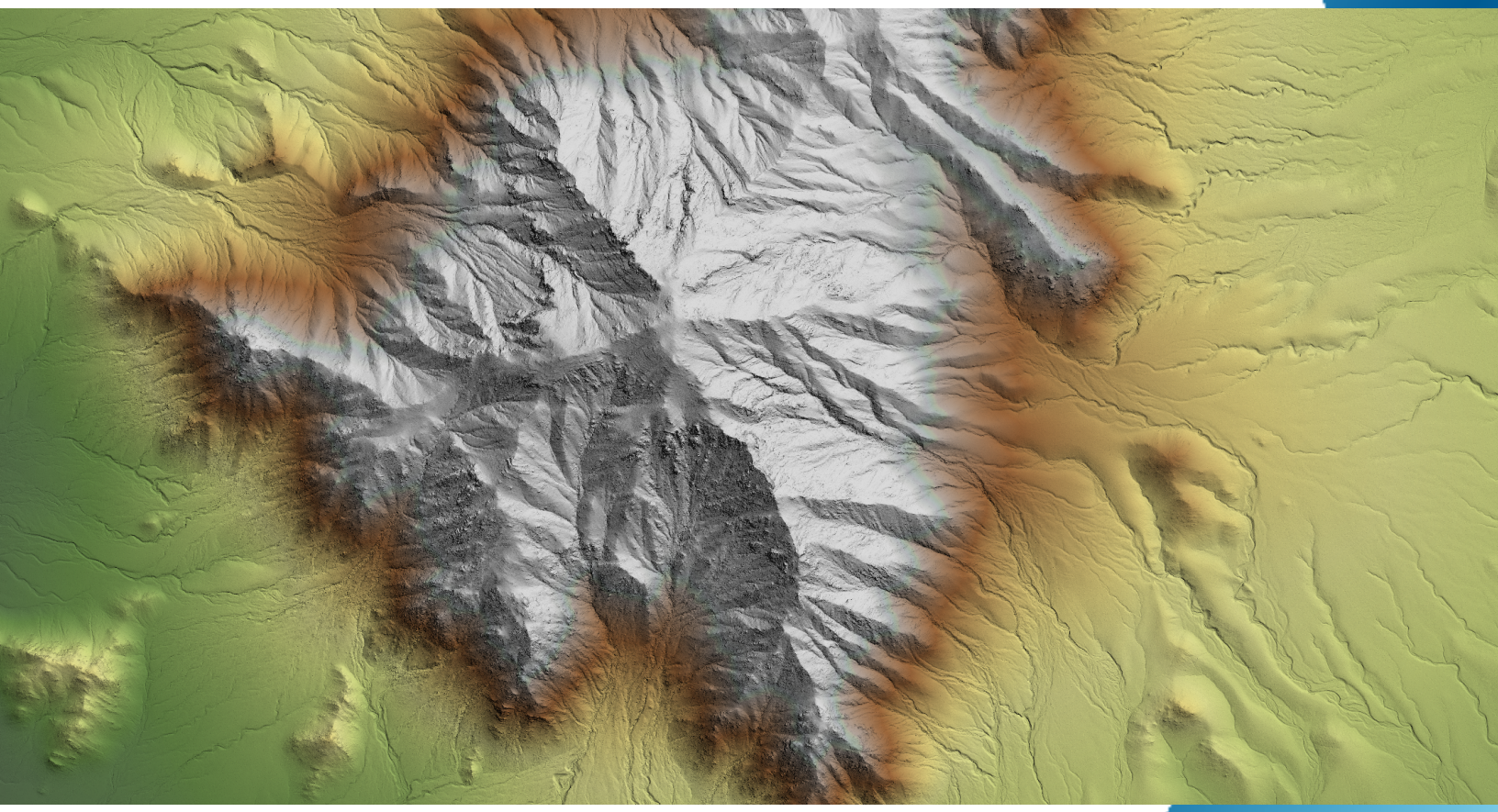
NV5 GEOSPATIAL



AZ_PIMACOUNTY LIDAR PROCESSING REPORT

2022

Project ID: 221897
Work Unit: 300020

Submitted: November 22, 2022

Prepared for:

USGS
science for a changing world

Prepared by:

NV5 GEOSPATIAL

Contents

List of Figures

List of Appendices

List of Tables

1. Summary / Scope

1.1. Summary

This report contains a summary of the AZ_PimaCounty, Work Unit 300020 lidar acquisition task order, issued by USGS under their Contract G16PC00016 on August 3, 2021. The task order yielded a project area covering 5374 square miles over Arizona. This project was done at Quality Level 1. 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
8pts / m2	1998 m	58.5°	20%	≤ 10 cm

1.3. Coverage

The project boundary covers 5374 square miles over Arizona. Project extents are shown in Figure 1.

1.4. Duration

Lidar data was acquired from September 27, 2021 to November 17, 2021 in 33 total lifts. See “Section: 2.4. Time Period” for more details.

1.5. Issues

There are no major issues to report.

AZ_PimaCounty Work Unit 300020 Projected Coordinate System: UTM Horizontal Datum: NAD83 (2011) Vertical Datum: NAVD88 (GEOID 18) Units: Meter	
Lidar Point Cloud	Classified Point Cloud in .LAS 1.4 format
Rasters	• 0.5-meter Hydro-flattened Bare Earth Digital Elevation Model (DEM) in GeoTIFF format • 0.5-meter Intensity images in GeoTIFF format • 0.5-meter First Return DSM in GeoTIFF format • 0.5-meter Height Separation in GeoTIFF format • 0.5-meter Maximum Surface Height Raster in GeoTIFF format
Vectors	Shapefiles (*.shp) • Project Boundary • Lidar Tile Index • Continuous Hydro-flattened Breaklines • Building Footprint Polygons Geodatabase (*.gdb) • Flight Index
Reports	Reports in PDF format • Project Report
Metadata	XML Files (*.xml) • Breaklines • Classified Point Cloud • DEM • Intensity Imagery

AZ_PimaCounty
Work Unit 300020 Boundary

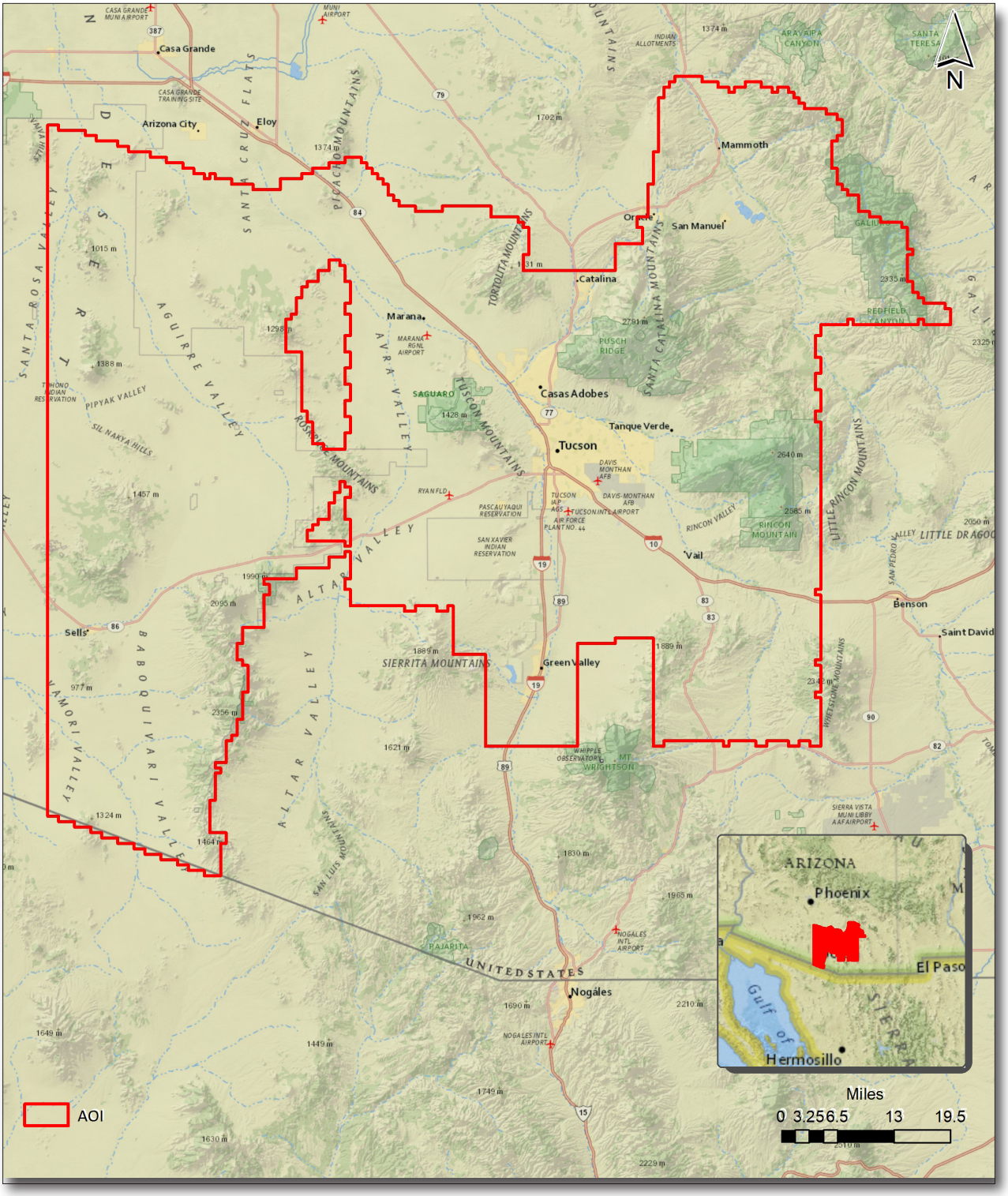


Figure 1. Work Unit Boundary

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 RiPARAMETER and FMS Planner planning software.

2.2. Lidar Sensor

NV5 Geospatial utilized Riegl VQ1560i, VQ 1560ii, and Optech Galaxy T2000 lidar sensors (Figure 2), serial numbers SN413, SN3061, SN3062 and SN4051, for data 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.

The Optech Galaxy T2000 is a wide-area lidar sensor. This sensor is enhanced with a continuous operating envelope, a dynamic field of view, real-time sensor protocol, and a high-performance scanner. This sensor has 2 MHz “on-ground” collection rates and is capable of 8 returns per emitted pulse.

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

Table 2. Lidar System Specifications

		Riegl VQ 1560i	Riegl VQ 1560ii	Optech Galaxy T2000
Terrain and Aircraft Scanner	Flying Height	2650 m	1710 m	2200 m
	Recommended Ground Speed	130 kts	140 kts	120 kts
Scanner	Field of View	58.5°	58.5°	58.5°
	Scan Rate Setting Used	187 Hz	322 Hz	268 Hz
Laser	Laser Pulse Rate Used	1400 kHz	2000 kHz	2200 kHz
Coverage	Full Swath Width	2969 m	1916 m	2465 m
	Line Spacing	1336 m	1533 m	1972 m
Point Spacing and Density	Average Point Spacing	0.612 m	0.477 m	0.466 m
	Average Point Density	4.7 pts / m^2	8 pts / m^2	9.64pts / m^2

Figure 2. Riegl and Optech 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 PA-31 (piston-multi), Tail Numbers: C-FFRY, C-GKSX
- Cessna 401B (piston-multi), Tail Numbers: N41GD
- Cessna Caravan (piston-single), Tail Numbers: N208JA

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 Riegl lidar system. Some of NV5 Geospatial's operating aircraft can be seen in Figure 3 below.

Figure 3. Some of NV5 Geospatial's Planes

2.4. Time Period

Project specific flights were conducted between November 06, 2021 and November 20, 2021. Thirty-three aircraft lifts were completed. Accomplished lifts are listed below.

Lift	Start UTC	End UTC
09272021A (SN413,N41GD)	9/27/2021 7:29:54 PM	9/28/2021 1:02:46 AM
09282021A (SN413,N41GD)	9/28/2021 3:41:10 PM	9/28/2021 6:48:43 PM
09282021B (SN413,N41GD)	9/28/2021 9:48:29 PM	9/29/2021 12:49:54 AM
09292021B (SN413,N41GD)	9/29/2021 2:57:52 PM	9/29/2021 5:40:40 PM
09292021C (SN413,N41GD)	9/29/2021 8:17:35 PM	9/29/2021 9:57:44 PM
09292021D (SN413,N41GD)	9/29/2021 10:33:01 PM	9/30/2021 1:04:43 AM
09302021B (SN413,N41GD)	10/01/2021 1:16:55 AM	10/01/2021 4:38:25 AM
10012021A (SN413,N41GD)	10/01/2021 8:18:24 PM	10/02/2021 12:59:07 AM
10022021A (SN413,N41GD)	10/02/2021 3:42:32 PM	10/02/2021 8:09:41 PM
10022021C (SN413,N41GD)	10/02/2021 11:43:28 PM	10/03/2021 1:38:33 AM
10032021A (SN413,N41GD)	10/03/2021 3:56:43 PM	10/03/2021 6:43:22 PM
10032021B (SN413,N41GD)	10/03/2021 7:11:49 PM	10/03/2021 8:57:11 PM
10032021C (SN413,N41GD)	10/03/2021 11:14:53 PM	10/04/2021 2:03:56 AM
10042021A (SN413,N41GD)	10/04/2021 3:04:34 PM	10/04/2021 7:07:29 PM
10052021A (SN413,N41GD)	10/05/2021 2:10:48 PM	10/05/2021 5:59:43 PM
10062021A (SN413,N41GD)	10/06/2021 2:27:52 PM	10/06/2021 6:55:38 PM
10062021B (SN413,N41GD)	10/06/2021 9:55:15 PM	10/07/2021 2:01:03 AM

Lift	Start UTC	End UTC
10072021A (SN413,N41GD)	10/07/2021 3:15:52 PM	10/07/2021 7:04:38 PM
10072021B (SN413,N41GD)	10/07/2021 10:34:16 PM	10/08/2021 1:16:06 AM
10242021A (SN3061,N208JA)	10/24/2021 3:50:21 PM	10/24/2021 10:06:37 PM
10252021A (SN3061,N208JA)	10/25/2021 3:57:44 PM	10/25/2021 9:41:10 PM
10262021A (SN3061,N208JA)	10/26/2021 8:57:37 PM	10/26/2021 11:43:50 PM
11072021A (SN4051,C-GKSX)	11/07/2021 4:05:13 PM	11/07/2021 9:28:01 PM
11082021A (SN4051,C-GKSX)	11/08/2021 3:50:26 PM	11/08/2021 9:11:46 PM
11092021A (SN4051,C-GKSX)	11/09/2021 3:47:10 PM	11/09/2021 8:01:24 PM
11122021A (SN3062,C-FFRY)	11/12/2021 4:25:14 PM	11/12/2021 9:18:28 PM
11122021A (SN4051,C-GKSX)	11/12/2021 9:00:57 PM	11/12/2021 9:06:05 PM
11142021A (SN3062,C-FFRY)	11/14/2021 4:00:25 PM	11/14/2021 4:06:33 PM
11152021A (SN3062,C-FFRY)	11/15/2021 3:33:24 PM	11/15/2021 3:40:35 PM
11162021A (SN3062,C-FFRY)	11/16/2021 3:40:43 PM	11/16/2021 8:44:39 PM
11162021A (SN4051,C-GKSX)	11/16/2021 6:13:41 PM	11/16/2021 8:51:47 PM
11172021A (SN3062,C-FFRY)	11/17/2021 4:09:44 PM	11/17/2021 7:46:50 PM
11172021A (SN4051,C-GKSX)	11/17/2021 5:36:40 PM	11/17/2021 7:48:16 PM

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.) Project specific flight logs for each sortie are available in Appendix A.

3.2. Lidar Processing

Applanix + POSPac software was 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 processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis includes: 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 the RiPROCESS and Optech LMS 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
Applanix + POSPac	8.6
Optech LMS	4.4
RiPROCESS	1.8.6
GeoCue	2020.1.22.1
Global Mapper	19.1;20.1
TerraModeler	21.008
TerraScan	21.016
TerraMatch	21.007

3.3. LAS Classification Scheme

The classification classes are determined by Lidar Base Specifications 2020, Revision A 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
3	Low Vegetation	Laser returns that are determined to be vegetation with 0-2m
4	Medium Vegetation	Laser returns that are determined to be vegetation with 2-6m
5	High Vegetation	Laser returns that are determined to be vegetation with 6+m
6	Buildings	Points falling on buildings, structures inside of water bodies, docks, and piers.
7	Low Noise	Laser returns that are often associated with scattering from reflective surfaces, or artificial points below the ground surface
9	Water	Laser returns that are found inside of hydro features
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
20	Ignored Ground	Ground points that fall within the given threshold of a collected hydro feature.

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 0.5-meter was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 20). 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. NV5 Geospatial'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 NV5 Geospatial'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 0.5-meter was also used around each hydro-flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 20).

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

Hydro-Flattened DEMs (topographic) represent a lidar-derived product illustrating the grounded terrain and associated breaklines (as described above) in raster form. NV5 Geospatial's proprietary software was used to take all input sources (bare earth lidar points, bridge and hydro breaklines, etc.) and create a Triangulated Irregular Network (TIN) on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper triangulation can occur. From the TIN, linear interpolation is used to calculate the cell values for the raster product. The raster product is then clipped back to the tile edge so that no overlapping cells remain

across the project area. A 32-bit floating point GeoTIFF DEM was generated for each tile with a pixel size of 0.5-meter.

NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each DEM is reviewed in Global Mapper to check for any surface anomalies and to ensure a seamless dataset. NV5 Geospatial ensures there are no void or no-data values (-999999) in each derived DEM. This is achieved by using propriety software checking all cell values that fall within the project boundary. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.

3.7. Intensity Image Processing

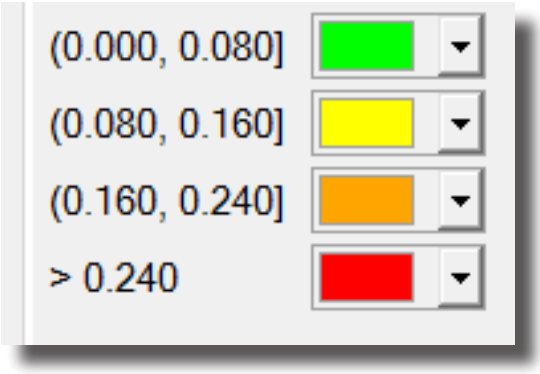
GeoCue software was used to create the deliverable intensity images. All withheld points were ignored during this process. This helps to ensure a more aesthetically pleasing image. The GeoCue software was then used to verify full project coverage as well. GeoTIFF files with a cell size of 0.5-meter were then provided as the deliverable for this dataset requirement.

3.8. Height Separation Raster Processing

wath Separation Images are rasters that represent the interswath alignment between flight lines and provide a qualitative evaluation of the positional quality of the point cloud. NV5 Geospatial proprietary software generated 0.5-meter raster images in GeoTIFF format using last returns, excluding points flagged with the withheld bit, and using a point-in-cell algorithm. Images are generated with a 75% intensity opacity and (4) absolute 8-cm intervals, see below (Figure 4) for interval coloring. Intensity images are linearly scaled to a value range specific to the project area to standardize the images and reduce differences between individual tiles.

Appropriate horizontal projection information as well as applicable header values are written to the file during product generation. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the images against what is required before final delivery.

Figure 4. Intervals for Swath Separation Images



3.9. Highest Hit Raster DSM Processing

First-return highest hit lidar points were used to create a 0.5-meter raster DSM. Using automated scripting routines within proprietary software, TIF files were created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.10. Maximum Surface Height Raster Processing

Maximum Surface Height rasters (topographic) represent a lidar-derived product illustrating natural and built-up features. NV5 Geospatial's proprietary software was used to take all first-return classified lidar points, excluding those flagged with a withheld bit, and create a Triangulated Irregular Network (TIN) on a tile-by-tile basis. Data extending past the tile edge is incorporated in this process so that proper triangulation can occur. From the TIN, linear interpolation is used to calculate the cell values for the raster product. The raster product is then clipped back to the tile edge so that no overlapping cells remain across the project area. A 32-bit floating point GeoTIFF was generated for each tile with a pixel size of 0.5-meter.

NV5 Geospatial's proprietary software was used to write appropriate horizontal and vertical projection information as well as applicable header values into the file during product generation. Each maximum surface height raster is reviewed in Global Mapper to check for any anomalies and to ensure a seamless dataset. NV5 Geospatial ensures there are no void or no-data values (-999999) in each derived raster. This is achieved by using propriety software checking all cell values that fall within the project boundary. NV5 Geospatial uses a proprietary tool called FOCUS on Delivery to check all formatting requirements of the DEMs against what is required before final delivery.

AZ_PimaCounty
Work Unit 300020 Tile Layout

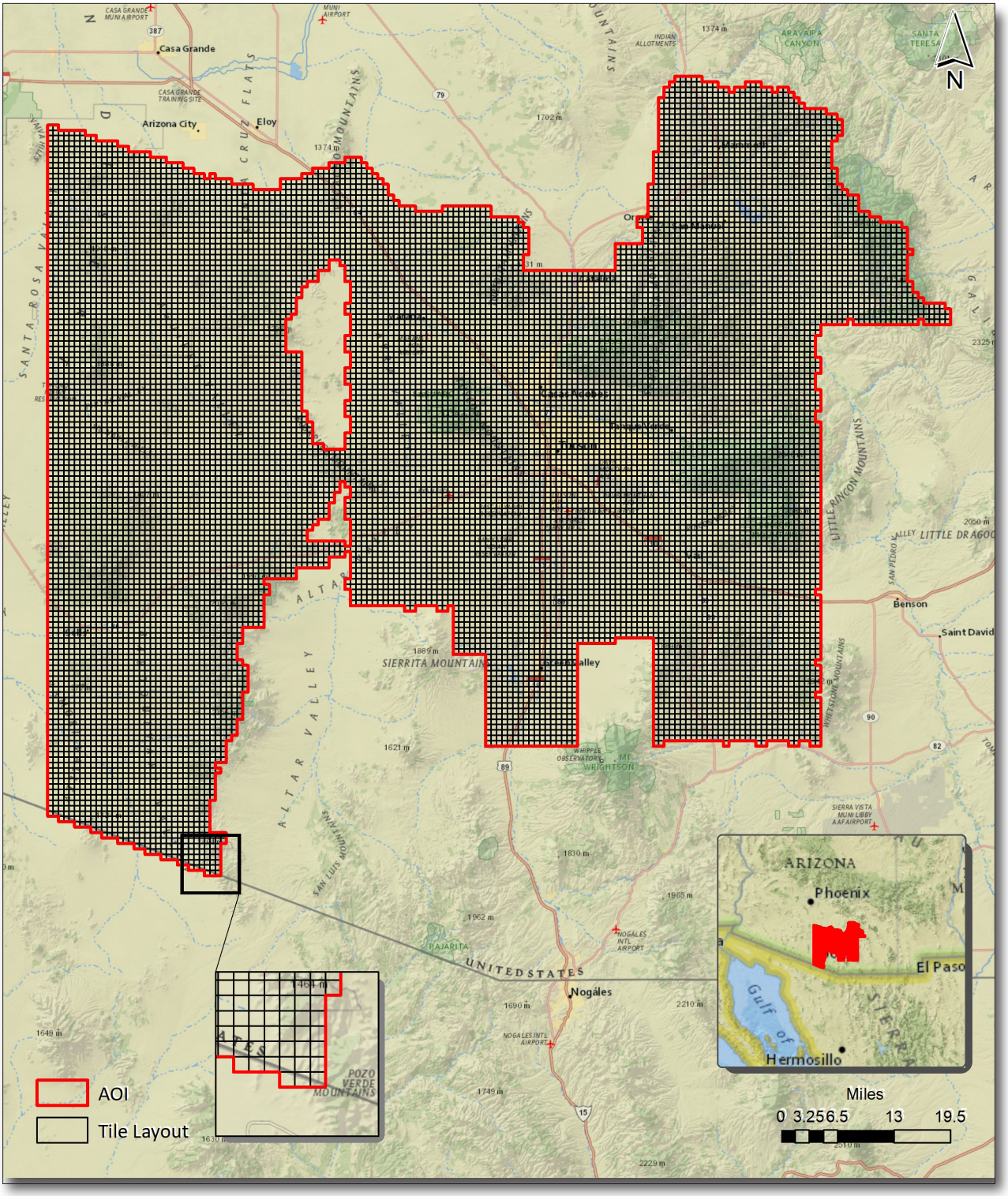


Figure 5. Lidar Tile Layout

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.

AZ_PimaCounty
Work Unit 300020 Lidar Coverage

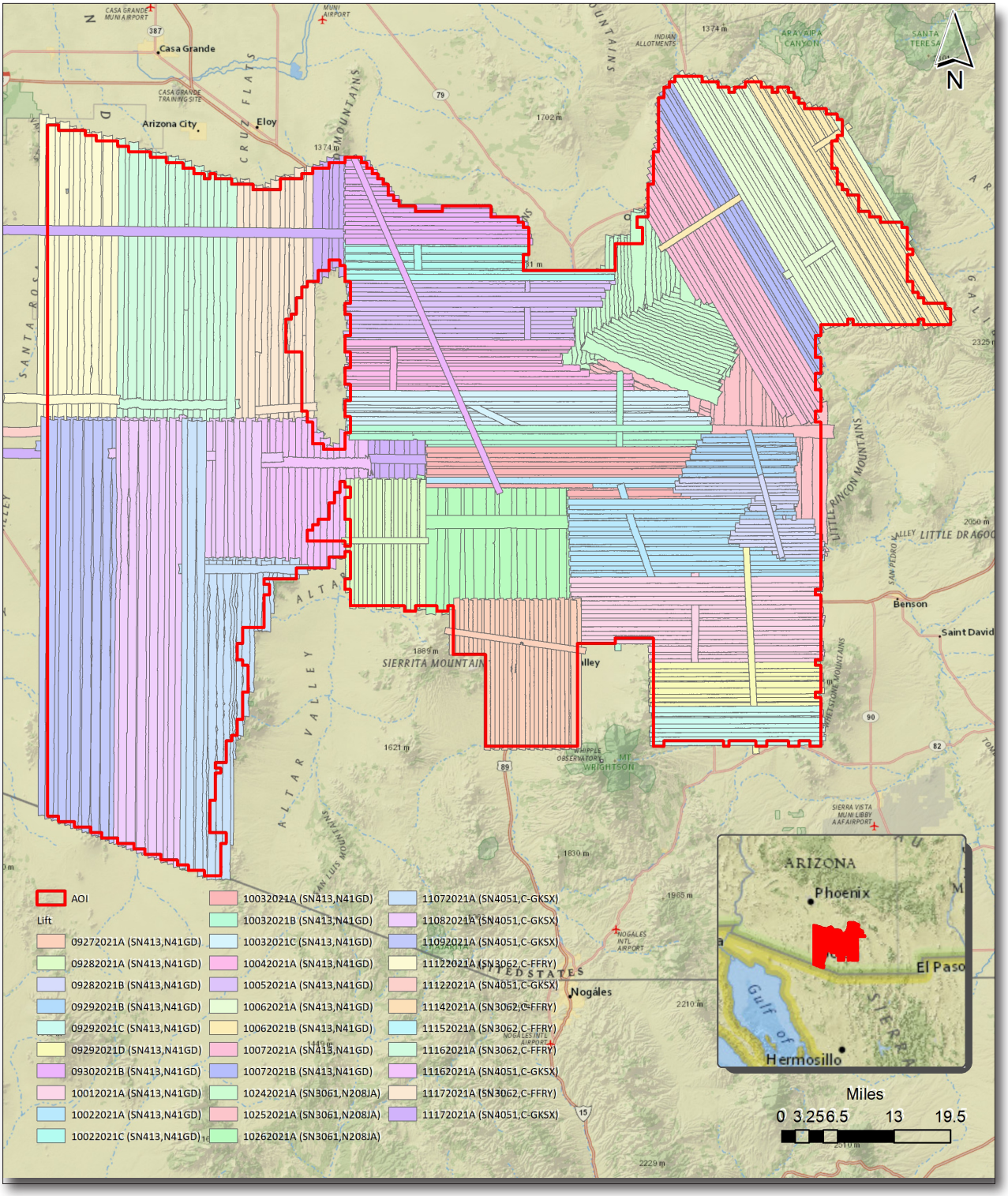


Figure 6. Lidar Coverage

5. Accuracy Testing

5.1. Calibration Control Point Testing

Figure 7 shows the location of each bare earth calibration point for the project area. TerraScan was used to perform a quality assurance check using the lidar bare earth calibration points. The results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

5.2. Point Cloud Testing

The project specifications require that only Non-Vegetated Vertical Accuracy (NVA) be computed for raw lidar point cloud swath files. The required accuracy (ACCz) is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. The NVA was tested with 191 checkpoints located in bare earth and urban (non-vegetated) areas. These check points were not used in the calibration or post processing of the lidar point cloud data. The checkpoints were distributed throughout the project area and were surveyed using GPS techniques. See survey report for additional survey methodologies.

Elevations from the unclassified lidar surface were measured for the x,y location of each check point. Elevations interpolated from the lidar surface were then compared to the elevation values of the surveyed control points. AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines.

5.3. Digital Elevation Model (DEM) Testing

The project specifications require the accuracy (ACCz) of the derived DEM be calculated and reported in two ways:

1. The required NVA is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. This is a required accuracy. The NVA was tested with 191 checkpoints located in bare earth and urban (non-vegetated) areas. See Figure 8.
2. Vegetated Vertical Accuracy (VVA): VVA shall be reported for "brushlands/low trees" and "tall weeds/crops" land cover classes. The target VVA is: 29.4 cm at the 95th percentile, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for lidar Data, i.e., based on the 95th percentile error in all vegetated land cover classes combined. This is a target accuracy. The VVA was tested with 138 checkpoints located in tall weeds/crops and brushlands/low trees (vegetated) areas. The checkpoints were distributed throughout the project area. See Figure 9.

AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASRPS Guidelines.

A brief summary of results are listed below.

	Target	Measured	Point Count
Raw NVA	0.196 m	0.1058	191
NVA	0.196 m	0.1656	191
VVA	0.294 m	0.1466	138

AZ_PimaCounty Work Unit 300020
Calibration Points

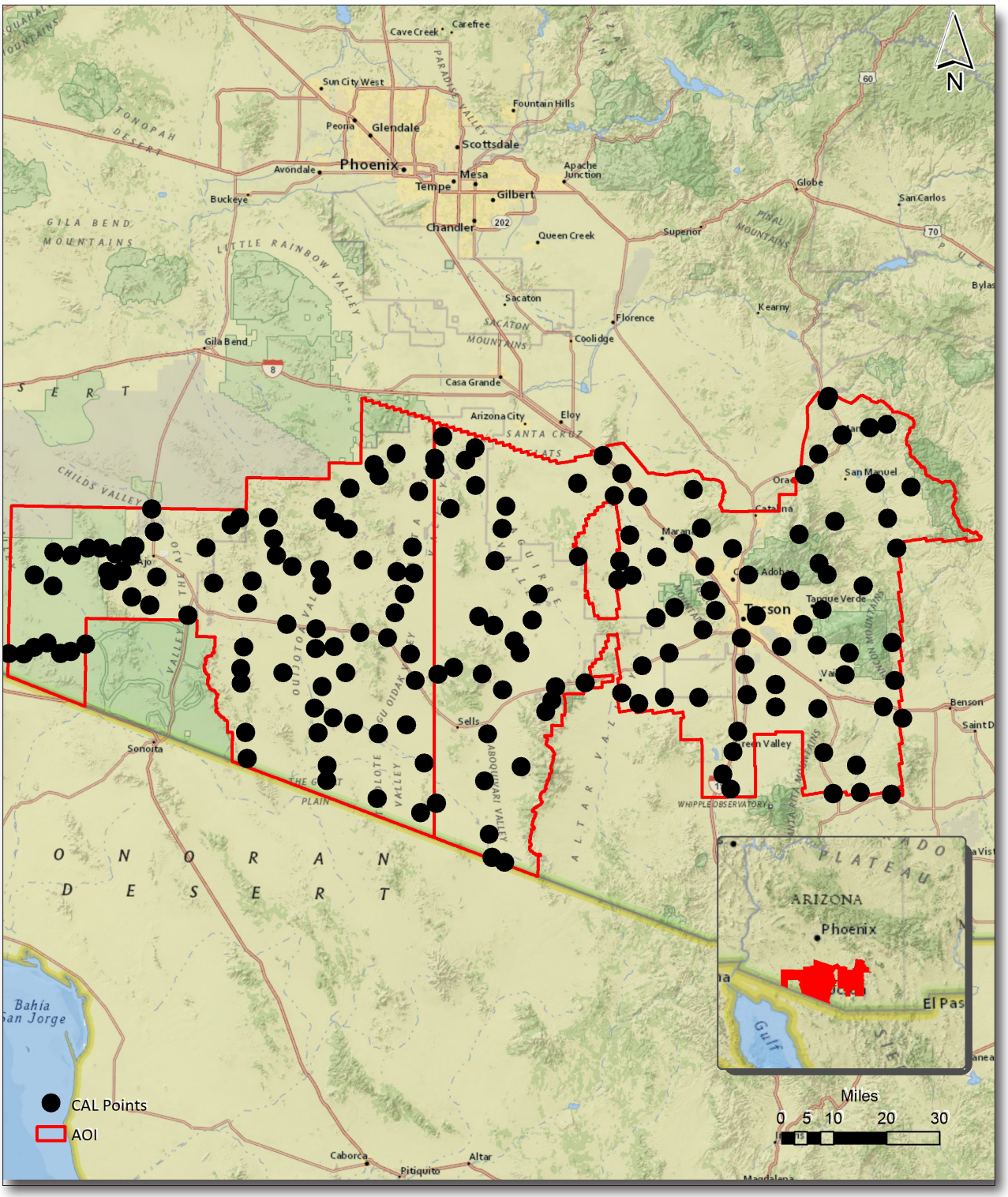


Figure 7. Calibration Control Point Locations

AZ_PimaCounty Work Unit 300020
NVA Points

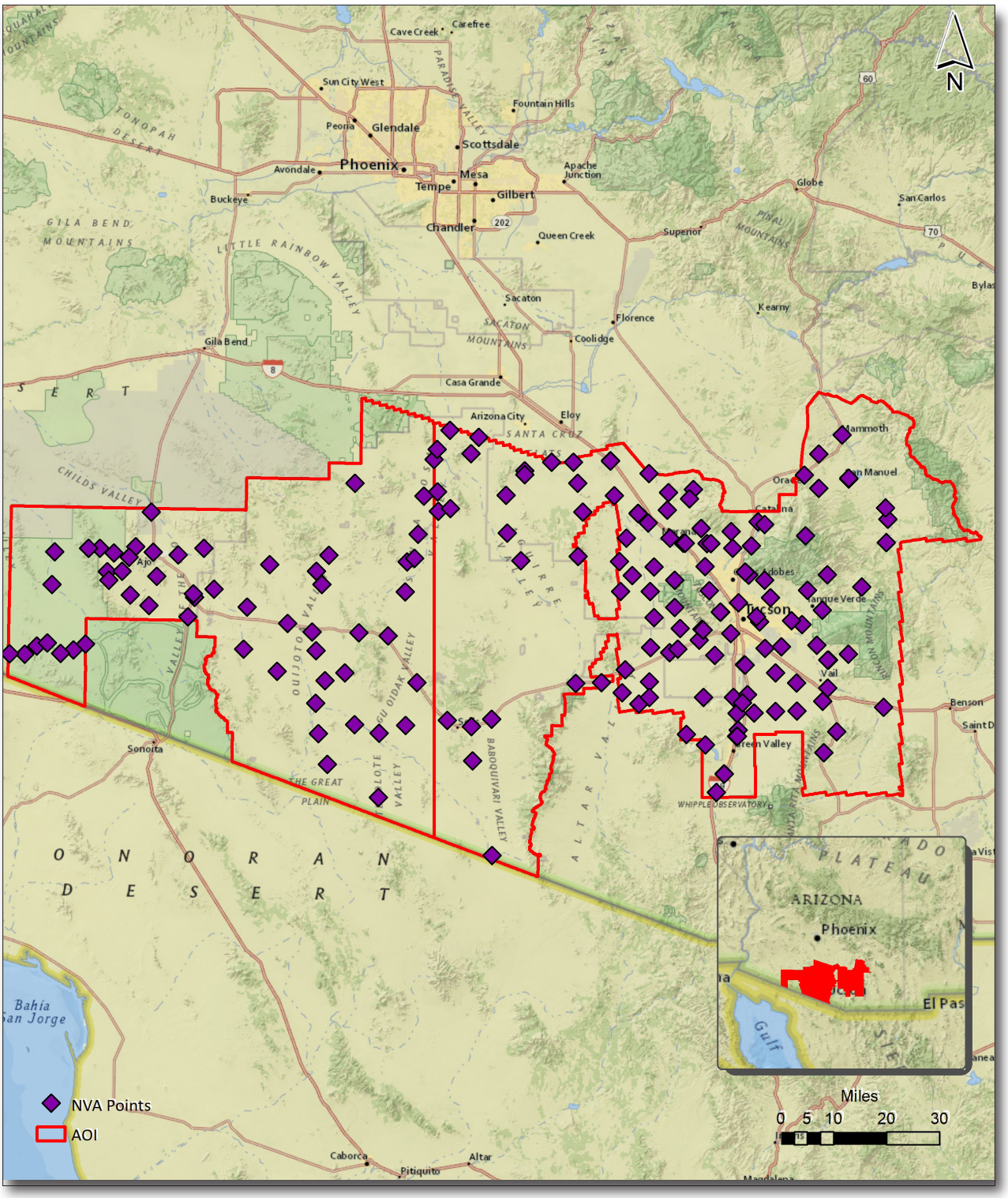


Figure 8. QC Checkpoint Locations - NVA

AZ_PimaCounty Work Unit 300020
VVA Points

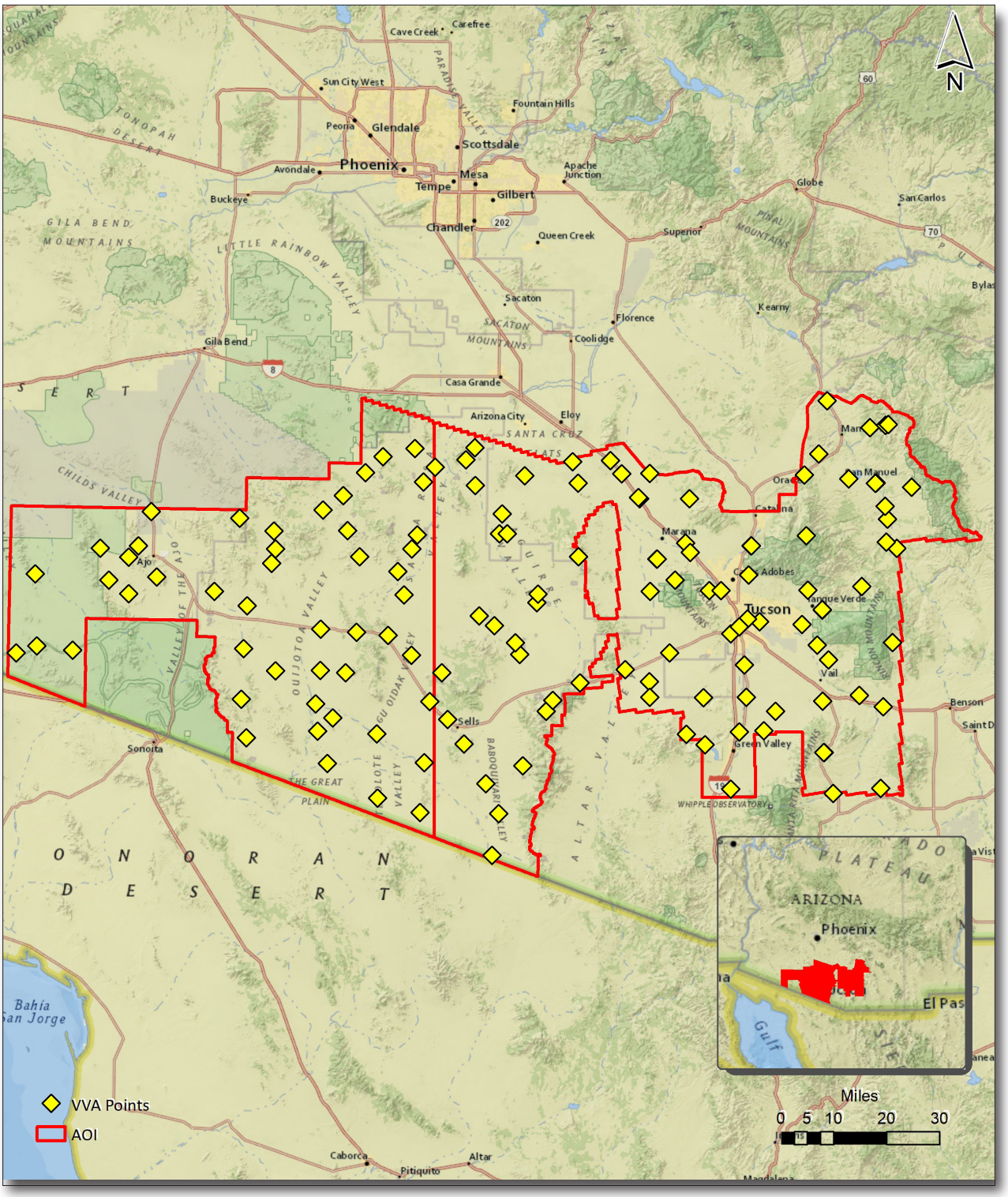


Figure 9. QC Checkpoint Locations - VVA

5. Geometric Accuracy

5.1. Horizontal Accuracy

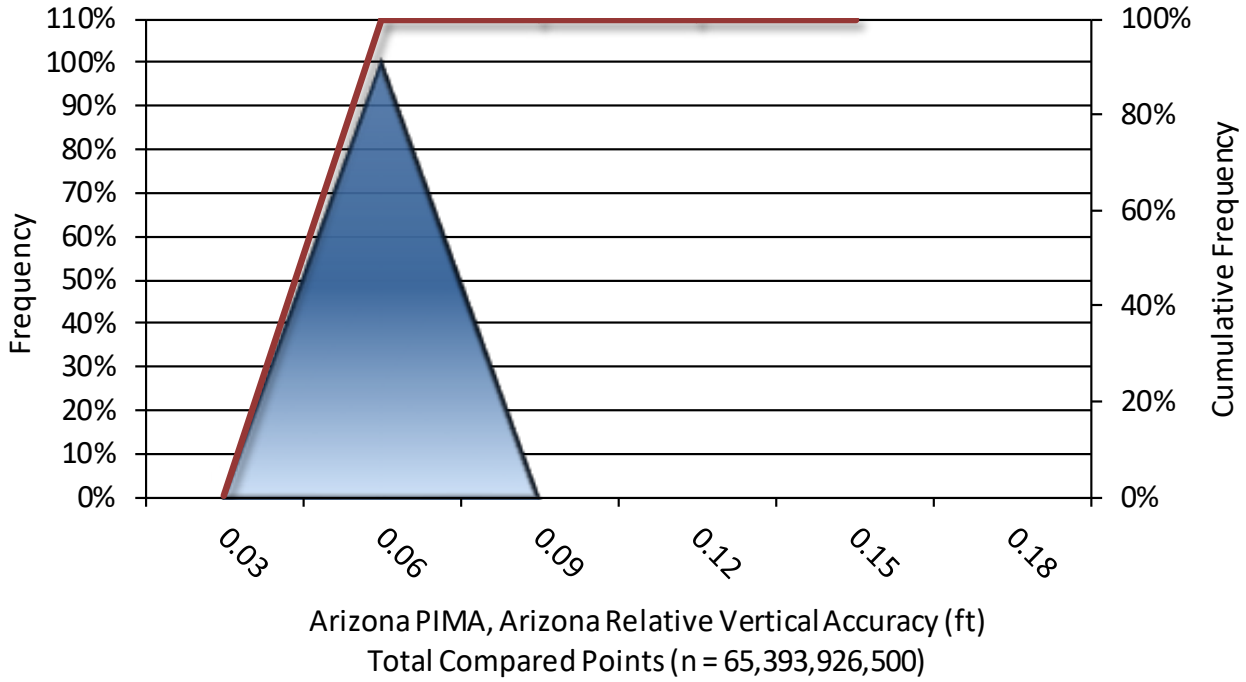
Lidar horizontal accuracy is a function of Global Navigation Satellite System (GNSS) derived positional error, flying altitude, and INS derived attitude error. The obtained $RMSE_r$ value is multiplied by a conversion factor of 1.7308 to yield the horizontal component of the National Standards for Spatial Data Accuracy (NSSDA) reporting standard where a theoretical point will fall within the obtained radius 95% of the time. Based on a flying altitude of 1710 meters, an IMU error of 0.002 decimal degrees, and a GNSS positional error of 0.015 meters, this project was compiled to meet 0.19 meter horizontal accuracy at the 95% confidence level. A summary is shown below.

Horizontal Accuracy	
$RMSE_r$	0.35 ft
	0.1078 m
ACC_r	0.61 ft
	0.19 m

5.2. Relative Vertical Accuracy

Relative vertical accuracy refers to the internal consistency of the data set as a whole: the ability to place an object in the same location given multiple flight lines, GPS conditions, and aircraft attitudes. When the lidar system is well calibrated, the swath-to-swath vertical divergence is low (<0.10 meters). The relative vertical accuracy was computed by comparing the ground surface model of each individual flight line with its neighbors in overlapping regions. The average (mean) line to line relative vertical accuracy for the AZ_PimaCounty project was 0.035 feet (0.011 meters). A summary is shown below.

Relative Vertical Accuracy	
Sample	193 flight line surfaces
Average	0.035 ft
	0.011 m
Median	0.035 ft
	0.011 m
RMSE	0.036 ft
	0.011 m
Standard Deviation (1σ)	0.004 ft
	0.001 m
1.96σ	0.007 ft
	0.002 m



Project Report Appendices

The following section contains the appendices as listed in the AZ_PimaCounty Lidar Project Report.

Appendix A

Flight Logs

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block023_Surv	

Mission	SEN5060413_20210927_F1	**Mission Notes**
Mission	9/27/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
23189	S	12:00:00	12:30:00		
23190	N	12:00:00	12:30:00		
23191	S	12:00:00	12:30:00		
23192	N	12:00:00	12:30:00		
23193	S	12:00:00	12:30:00		Reflown 10/7- Refly 0-3 statute miles FSE due to excessive noise and dropouts
23194	N	12:00:00	12:30:00		
23195	S	12:00:00	12:30:00		
23196	N	12:00:00	12:30:00		
23197	S	12:00:00	12:30:00		
23198	N	12:00:00	12:30:00		
23199	S	12:00:00	12:30:00		
23200	N	12:00:00	12:30:00		
23201	S	12:00:00	12:30:00		
23202	N	12:00:00	12:30:00		
23203	S	12:00:00	12:30:00		
23204	N	12:00:00	12:30:00		
23205	S	12:00:00	12:30:00		
23206	N	12:00:00	12:30:00		
23207	S	12:00:00	12:30:00		
23208	N	12:00:00	12:30:00		
23209	S	12:00:00	12:30:00		
23210	N	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block03_Surv	

Mission	SEN5060413_20210928_F1	**Mission Notes**
Mission	9/28/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
03001	S	12:00:00	12:30:00		
03002	N	12:00:00	12:30:00		
03003	S	12:00:00	12:30:00		
03004	N	12:00:00	12:30:00		
03005	S	12:00:00	12:30:00		
03006	N	12:00:00	12:30:00		
03007	S	12:00:00	12:30:00		
03008	N	12:00:00	12:30:00		
03009	S	12:00:00	12:30:00		
03010	N	12:00:00	12:30:00		
03011	S	12:00:00	12:30:00		
03012	N	12:00:00	12:30:00		
03013	S	12:00:00	12:30:00		
03014	N	12:00:00	12:30:00		
03015	S	12:00:00	12:30:00		
03016	N	12:00:00	12:30:00		
03017	S	12:00:00	12:30:00		
03018	N	12:00:00	12:30:00		
03019	E	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block022_Surv	

Mission	SEN5060413_20210928_F2	**Mission Notes**
Mission	9/28/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
22149	E	12:00:00	12:30:00		
22150	SW	12:00:00	12:30:00		
22151	E	12:00:00	12:30:00		
22152	SW	12:00:00	12:30:00		
22153	E	12:00:00	12:30:00		
22154	SW	12:00:00	12:30:00		
22155	E	12:00:00	12:30:00		
22156	SW	12:00:00	12:30:00		
22157	E	12:00:00	12:30:00		
22158	SW	12:00:00	12:30:00		
22162	SW	12:00:00	12:30:00		Cloud
22163	E	12:00:00	12:30:00		
22164	SW	12:00:00	12:30:00		
22165	E	12:00:00	12:30:00		
22166	SW	12:00:00	12:30:00		
22167	E	12:00:00	12:30:00		
22168	SW	12:00:00	12:30:00		
22169	E	12:00:00	12:30:00		
22170	SW	12:00:00	12:30:00		
22171	E	12:00:00	12:30:00		
22172	SW	12:00:00	12:30:00		
22188	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20210929_F2	**Mission Notes**
Mission	9/29/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21001	E	12:00:00	12:30:00		
21002	SW	12:00:00	12:30:00		
21003	E	12:00:00	12:30:00		
21004	SW	12:00:00	12:30:00		
21005	E	12:00:00	12:30:00		
21006	SW	12:00:00	12:30:00		
21007	E	12:00:00	12:30:00		
21008	SW	12:00:00	12:30:00		
21009	E	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20210929_F3	**Mission Notes**
Mission	9/29/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21010	SW	12:00:00	12:30:00		
21011	E	12:00:00	12:30:00		
21012	SW	12:00:00	12:30:00		
21013	E	12:00:00	12:30:00		
21014	SW	12:00:00	12:30:00		
21015	E	12:00:00	12:30:00		
21016	SW	12:00:00	12:30:00		
21017	E	12:00:00	12:30:00		
21018	SW	12:00:00	12:30:00		
21019	E	12:00:00	12:30:00		
21020	SW	12:00:00	12:30:00		
21021	E	12:00:00	12:30:00		
21148	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block022_Surv	

Mission	SEN5060413_20210929_F1	**Mission Notes**
Mission	9/29/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
22159	E	12:00:00	12:30:00		
22160	SW	12:00:00	12:30:00		
22161	E	12:00:00	12:30:00		
22162	SW	12:00:00	12:30:00		
22173	E	12:00:00	12:30:00		
22174	SW	12:00:00	12:30:00		
22175	E	12:00:00	12:30:00		
22176	SW	12:00:00	12:30:00		
22177	E	12:00:00	12:30:00		
22178	SW	12:00:00	12:30:00		
22179	E	12:00:00	12:30:00		
22180	SW	12:00:00	12:30:00		
22181	E	12:00:00	12:30:00		
22182	SW	12:00:00	12:30:00		
22183	E	12:00:00	12:30:00		
22184	SW	12:00:00	12:30:00		
22185	E	12:00:00	12:30:00		
22186	SW	12:00:00	12:30:00		
22187	E	12:00:00	12:30:00		
22188	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20210930_F1	**Mission Notes**
Mission	9/30/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21126	SW	12:00:00	12:30:00		
21127	E	12:00:00	12:30:00		
21128	SW	12:00:00	12:30:00		
21129	E	12:00:00	12:30:00		
21130	SW	12:00:00	12:30:00		
21131	E	12:00:00	12:30:00		
21132	SW	12:00:00	12:30:00		
21133	E	12:00:00	12:30:00		
21134	SW	12:00:00	12:30:00		
21135	E	12:00:00	12:30:00		
21136	SW	12:00:00	12:30:00		
21137	E	12:00:00	12:30:00		
21138	SW	12:00:00	12:30:00		
21139	E	12:00:00	12:30:00		
21140	SW	12:00:00	12:30:00		
21141	E	12:00:00	12:30:00		
21142	SW	12:00:00	12:30:00		
21143	E	12:00:00	12:30:00		
21144	SW	12:00:00	12:30:00		
21145	E	12:00:00	12:30:00		
21146	SE	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20211001_F1	**Mission Notes**
Mission	10/1/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21022	SW	12:00:00	12:30:00		
21023	E	12:00:00	12:30:00		
21024	SW	12:00:00	12:30:00		
21025	E	12:00:00	12:30:00		
21026	SW	12:00:00	12:30:00		
21027	E	12:00:00	12:30:00		
21028	SW	12:00:00	12:30:00		
21029	E	12:00:00	12:30:00		
21030	SW	12:00:00	12:30:00		
21031	E	12:00:00	12:30:00		
21032	SW	12:00:00	12:30:00		
21033	E	12:00:00	12:30:00		
21034	SW	12:00:00	12:30:00		
21035	E	12:00:00	12:30:00		
21036	SW	12:00:00	12:30:00		
21037	E	12:00:00	12:30:00		
21038	SW	12:00:00	12:30:00		
21039	E	12:00:00	12:30:00		
21040	SW	12:00:00	12:30:00		
21041	E	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20211002_F1	**Mission Notes**
Mission	10/2/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (l		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21042	SW	12:00:00	12:30:00		
21043	E	12:00:00	12:30:00		
21044	SW	12:00:00	12:30:00		
21045	E	12:00:00	12:30:00		
21046	SW	12:00:00	12:30:00		
21047	E	12:00:00	12:30:00		
21048	SW	12:00:00	12:30:00		
21049	E	12:00:00	12:30:00		
21050	SW	12:00:00	12:30:00		
21051	E	12:00:00	12:30:00		
21052	SW	12:00:00	12:30:00		
21053	E	12:00:00	12:30:00		
21054	SW	12:00:00	12:30:00		
21055	E	12:00:00	12:30:00		
21056	SW	12:00:00	12:30:00		
21057	E	12:00:00	12:30:00		
21058	SW	12:00:00	12:30:00		
21059	E	12:00:00	12:30:00		
21064	SW	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20211002_F3	**Mission Notes**
Mission	10/2/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21117	E	12:00:00	12:30:00		
21118	SW	12:00:00	12:30:00		
21119	E	12:00:00	12:30:00		
21120	SW	12:00:00	12:30:00		
21121	E	12:00:00	12:30:00		
21122	SW	12:00:00	12:30:00		
21123	E	12:00:00	12:30:00		
21124	SW	12:00:00	12:30:00		
21125	E	12:00:00	12:30:00		

Mission	SEN5060413_20211003_F2	**Mission Notes**
Mission	10/3/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21072	SW	12:00:00	12:30:00		
21073	E	12:00:00	12:30:00		
21074	SW	12:00:00	12:30:00		
21075	E	12:00:00	12:30:00		
21076	SW	12:00:00	12:30:00		
21147	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20211003_F3	**Mission Notes**
Mission	10/3/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21077	E	12:00:00	12:30:00		
21078	SW	12:00:00	12:30:00		
21079	E	12:00:00	12:30:00		
21080	SW	12:00:00	12:30:00		
21081	E	12:00:00	12:30:00		
21082	SW	12:00:00	12:30:00		
21083	E	12:00:00	12:30:00		
21084	SW	12:00:00	12:30:00		
21085	E	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block021_Surv	

Mission	SEN5060413_20211004_F1	**Mission Notes**
Mission	10/4/2021	Flight
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21086	SW	12:00:00	12:30:00		
21087	E	12:00:00	12:30:00		
21088	SW	12:00:00	12:30:00		
21089	E	12:00:00	12:30:00		
21090	SW	12:00:00	12:30:00		
21091	E	12:00:00	12:30:00		
21092	SW	12:00:00	12:30:00		
21093	E	12:00:00	12:30:00		
21094	SW	12:00:00	12:30:00		
21095	E	12:00:00	12:30:00		
21096	SW	12:00:00	12:30:00		
21097	E	12:00:00	12:30:00		
21098	SW	12:00:00	12:30:00		
21099	E	12:00:00	12:30:00		
21100	SW	12:00:00	12:30:00		
21101	E	12:00:00	12:30:00		

Mission	SEN5060413_20211005_F14	**Mission Notes**
Mission	10/5/2021	Continue acquisition if wx allows
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
21102	SW	12:00:00	12:30:00		
21103	E	12:00:00	12:30:00		
21104	SW	12:00:00	12:30:00		
21105	E	12:00:00	12:30:00		
21106	SW	12:00:00	12:30:00		
21107	E	12:00:00	12:30:00		
21108	SW	12:00:00	12:30:00		
21109	E	12:00:00	12:30:00		
21110	SW	12:00:00	12:30:00		
21111	E	12:00:00	12:30:00		
21112	SW	12:00:00	12:30:00		
21113	E	12:00:00	12:30:00		
21114	SW	12:00:00	12:30:00		
21115	E	12:00:00	12:30:00		
21116	SW	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	Block01_Surv	

Mission	SEN5060413_20211006_F15	**Mission Notes**
Mission	10/6/2021	continue acq until complete
Aircraft	N41GD	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	SURVTECH	
Base Air	ktus	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
01001	SE	12:00:00	12:30:00		
01002	NW	12:00:00	12:30:00		
01003	SE	12:00:00	12:30:00		
01004	NW	12:00:00	12:30:00		
01005	SE	12:00:00	12:30:00		
01006	NW	12:00:00	12:30:00		
01007	SE	12:00:00	12:30:00		
01008	NW	12:00:00	12:30:00		
01009	SE	12:00:00	12:30:00		
01010	NW	12:00:00	12:30:00		
01011	SE	12:00:00	12:30:00		
01012	NW	12:00:00	12:30:00		
01013	SE	12:00:00	12:30:00		
01014	NW	12:00:00	12:30:00		
01015	SE	12:00:00	12:30:00		
01016	NW	12:00:00	12:30:00		
01017	SE	12:00:00	12:30:00		
01018	NW	12:00:00	12:30:00		
01019	SE	12:00:00	12:30:00		
01020	NW	12:00:00	12:30:00		
01021	SE	12:00:00	12:30:00		
01022	NW	12:00:00	12:30:00		
01023	SE	12:00:00	12:30:00		
01024	NW	12:00:00	12:30:00		
01025	SE	12:00:00	12:30:00		
01026	NW	12:00:00	12:30:00		
01027	SE	12:00:00	12:30:00		
01028	NW	12:00:00	12:30:00		
01029	SE	12:00:00	12:30:00		
01051	NE	12:00:00	12:30:00		

Project	947121-R037174.00 AZ_PimaCounty_2021_D21
Flightpla	37174_PAG2021_PAG_1560s_55SL_8ppsm_BK7

Mission	S2223061_20211024_F1	Mission Notes
Mission	10/24/2021	
Aircraft	N208JA	
Pilot	Daniel Luckett	
Co-Pilot		
Operato	Mark Smith	
Co-Oper		
Vendor	NV5 Geospatial	
Base Air	ktus	
Departu	8:32:00 AM	
Arrival (I	3:27:00 PM	

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
07001	N	15:50:20	15:51:05	132.1	
07001	N	15:52:28	15:52:43	138.3	
07001	S	15:55:07	15:57:12	129.4	
07002	N	15:58:43	16:00:33	129.5	
00666	N	16:02:10	16:02:21	129.9	
07003	S	16:04:30	16:07:53	129.1	
07004	N	16:09:28	16:13:17	132.0	
07005	S	16:15:07	16:18:37	138.8	
07006	N	16:20:17	16:23:51	130.9	
07007	S	16:25:28	16:28:59	128.5	
07008	N	16:30:28	16:33:47	131.1	
07009	S	16:35:42	16:39:16	130.5	
07010	N	16:40:47	16:44:20	128.5	
07011	S	16:46:21	16:50:03	130.2	
07012	N	16:51:40	16:55:32	130.1	
07013	S	16:57:15	17:01:20	128.6	
07014	N	17:02:50	17:08:05	128.8	
07015	S	17:09:35	17:14:41	129.1	
07016	N	17:16:15	17:21:19	127.8	
07017	S	17:22:45	17:27:33	131.5	
07018	N	17:29:20	17:34:06	130.3	
07019	S	17:35:45	17:40:27	129.6	
07020	N	17:42:14	17:46:48	130.1	
07021	S	17:49:36	17:55:18	130.4	
07022	N	17:56:57	18:02:30	131.1	
07023	S	18:04:09	18:09:40	129.8	
07024	N	18:11:40	18:17:05	131.3	
07025	S	18:18:39	18:24:05	129.3	
07026	N	18:25:49	18:31:20	126.0	
07027	S	18:32:55	18:38:09	131.4	
07028	N	18:39:52	18:45:02	130.2	
07029	S	18:46:41	18:51:42	132.3	
07030	N	18:53:13	18:58:14	130.0	
07031	S	18:59:48	19:04:39	131.6	
07032	N	19:06:06	19:11:02	126.6	
07033	S	19:12:36	19:17:16	130.6	
07034	N	19:18:48	19:23:04	126.3	
07035	S	19:24:31	19:28:36	128.5	
07036	N	19:30:09	19:32:26	129.8	
07037	E	19:36:04	19:37:51	132.4	
07038	SW	19:39:43	19:42:01	126.9	
07039	E	19:43:55	19:46:27	132.8	
07040	SW	19:48:04	19:51:00	127.9	
07041	E	19:52:38	19:55:46	132.1	
07042	SW	19:57:32	20:00:52	133.0	
07043	E	20:02:06	20:05:48	130.1	

07044	SW	20:06:57	20:10:56	127.3
07045	E	20:12:17	20:16:20	131.3
07046	SW	20:17:42	20:21:52	133.8
07047	E	20:23:05	20:27:44	126.0
07048	SW	20:29:18	20:33:54	131.0
07049	E	20:35:11	20:39:57	131.0
07050	SW	20:41:09	20:46:13	128.3
07051	E	20:47:40	20:52:54	128.8
07052	SW	20:54:17	20:59:36	131.5
07053	E	21:01:10	21:06:41	131.0
07054	SW	21:07:58	21:13:42	130.6
07055	E	21:15:05	21:20:51	127.7
07056	SW	21:22:16	21:27:58	128.9
07057	E	21:29:34	21:35:30	129.8
07058	SW	21:36:42	21:42:48	130.4
07059	E	21:44:20	21:50:42	129.2
07060	SW	21:51:40	21:58:09	129.9
07061	E	21:59:51	22:06:37	128.5

Project	947121-R037174.00 AZ_PimaCounty_2021_D21
Flightpla	37174_PAG2021_PAG_1560s_55SL_8ppsm_BK7

Mission	S2223061_20211025_F1	Mission Notes
Mission	10/25/2021	
Aircraft	N208JA	
Pilot	Daniel Luckett	
Co-Pilot		
Operato	Mark Smith	
Co-Oper		
Vendor	NV5 Geospatial	
Base Air	ktus	
Departu	8:39:00 AM	
Arrival (l	2:55:00 PM	

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
07101	N	15:57:43	16:05:29	129.2	
07100	SW	16:07:57	16:18:02	123.5	
07062	E	16:22:16	16:29:20	125.9	
07063	SW	16:30:42	16:37:50	128.9	
07064	E	16:39:41	16:46:54	132.0	
07065	SW	16:48:40	16:56:00	132.9	
07066	E	16:57:42	17:05:19	131.7	
07067	SW	17:06:40	17:14:33	130.3	
07068	E	17:15:57	17:23:56	130.0	
07069	SW	17:25:27	17:33:11	131.6	
07070	S	17:41:27	17:45:33	130.3	
07071	N	17:48:24	17:52:34	128.4	
07072	S	17:54:23	17:58:35	126.9	
07073	N	18:00:02	18:04:04	132.4	
07074	S	18:09:00	18:16:33	128.2	
07075	N	18:18:09	18:25:26	132.3	
07076	S	18:27:34	18:34:46	126.5	
07077	N	18:36:20	18:43:27	127.9	
07078	S	18:45:22	18:52:13	124.4	
07079	N	18:53:54	18:59:53	128.7	
07080	S	19:01:50	19:07:19	127.6	
07081	N	19:09:00	19:14:06	131.6	
07082	S	19:16:07	19:21:03	125.5	
07083	N	19:22:35	19:27:29	125.4	
07084	S	19:29:17	19:34:01	128.9	
07085	N	19:36:11	19:39:16	125.7	
07086	S	19:41:02	19:43:59	130.9	
07087	N	19:49:45	19:56:00	131.4	
07088	S	19:57:53	20:04:19	127.2	
07089	N	20:05:46	20:11:55	128.3	
07090	S	20:13:47	20:19:54	129.0	
07091	N	20:21:31	20:27:39	128.9	
07092	S	20:29:31	20:35:51	127.6	
07093	N	20:37:34	20:43:56	128.9	
07094	S	20:45:33	20:51:57	130.5	
07094	N	20:57:56	21:04:31	126.9	
07094	SW	21:08:20	21:14:56	131.0	
07094	S	21:19:47	21:22:04	130.0	
07094	N	21:24:12	21:26:36	128.7	
07094	S	21:28:49	21:31:08	129.4	
07094	N	21:33:02	21:35:24	128.3	
07094	SW	21:38:44	21:41:10	122.4	

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	37174_PAG2021_PAG_1560s_20SL_8ppsm_BK6	

Mission	S2223061_20211026_F1	**Mission Notes**
Mission	10/26/2021	
Aircraft	N208JA	
Pilot	Daniel Luckett	
Co-Pilot		
Operato	Mark Smith	
Co-Oper		
Vendor	NV5 Geospatial	
Base Air	ktus	
Departu	1:34:00 PM	
Arrival (l	5:02:00 PM	

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
06001	N	20:57:36	21:04:12	122.0	
06002	S	21:06:05	21:12:51	120.5	
06003	N	21:14:54	21:21:41	120.8	
06004	S	21:23:16	21:30:05	120.1	
06005	N	21:31:53	21:38:43	119.4	
06006	S	21:40:08	21:46:54	119.7	
06007	N	21:48:29	21:55:14	119.0	
06008	S	21:56:35	22:03:22	118.8	
06009	N	22:04:50	22:11:35	119.1	
06010	S	22:13:10	22:19:46	121.9	
06011	N	22:21:10	22:28:03	116.5	
06012	S	22:29:36	22:36:22	118.5	
06013	N	22:38:01	22:44:55	116.1	
06014	S	22:46:22	22:53:07	119.0	
06015	N	22:55:23	23:02:06	119.4	
06016	S	23:03:57	23:10:48	117.2	
06017	N	23:12:45	23:19:29	119.0	
06018	S	23:21:25	23:28:26	114.4	
06019	SW	23:34:50	23:43:50	117.8	

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211107_F1	**Mission Notes**
Mission	11/7/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05215	N	12:00:00	12:30:00		
05216	N	12:00:00	12:30:00		
05217	N	12:00:00	12:30:00		
05218	N	12:00:00	12:30:00		
05254	N	12:00:00	12:30:00		
05255	N	12:00:00	12:30:00		
05256	N	12:00:00	12:30:00		
05257	N	12:00:00	12:30:00		
05258	N	12:00:00	12:30:00		
05259	N	12:00:00	12:30:00		
05260	N	12:00:00	12:30:00		
05261	N	12:00:00	12:30:00		
05262	N	12:00:00	12:30:00		Patch reflight needed for mountain shadow dropout/lack of overlap
05263	N	12:00:00	12:30:00		Patch reflight needed for mountain shadow dropout/lack of overlap
05264	N	12:00:00	12:30:00		
05265	N	12:00:00	12:30:00		
05266	N	12:00:00	12:30:00		
05267	N	12:00:00	12:30:00		
05268	N	12:00:00	12:30:00		
05269	N	12:00:00	12:30:00		
05270	N	12:00:00	12:30:00		
05271	N	12:00:00	12:30:00		
05272	N	12:00:00	12:30:00		
05273	N	12:00:00	12:30:00		
05274	N	12:00:00	12:30:00		
05275	N	12:00:00	12:30:00		
05276	N	12:00:00	12:30:00		
05281	SW	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211108_F1	**Mission Notes**
Mission	11/8/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05203	N	12:00:00	12:30:00		
05204	N	12:00:00	12:30:00		
05205	N	12:00:00	12:30:00		
05206	N	12:00:00	12:30:00		
05207	N	12:00:00	12:30:00		
05208	N	12:00:00	12:30:00		
05209	N	12:00:00	12:30:00		
05210	N	12:00:00	12:30:00		
05211	N	12:00:00	12:30:00		
05212	N	12:00:00	12:30:00		Refly 0-31 statute miles FSE due to Channel 1 drop.
05213	N	12:00:00	12:30:00		
05214	N	12:00:00	12:30:00		
05219	N	12:00:00	12:30:00		
05220	N	12:00:00	12:30:00		
05221	N	12:00:00	12:30:00		
05222	N	12:00:00	12:30:00		
05223	N	12:00:00	12:30:00		
05224	N	12:00:00	12:30:00		
05225	N	12:00:00	12:30:00		
05226	N	12:00:00	12:30:00		
05227	N	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211109_F1	**Mission Notes**
Mission	11/9/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05189	N	12:00:00	12:30:00		
05190	N	12:00:00	12:30:00		
05191	N	12:00:00	12:30:00		
05192	N	12:00:00	12:30:00		
05193	N	12:00:00	12:30:00		
05194	N	12:00:00	12:30:00		
05195	N	12:00:00	12:30:00		
05196	N	12:00:00	12:30:00		
05197	N	12:00:00	12:30:00		
05198	N	12:00:00	12:30:00		
05199	N	12:00:00	12:30:00		
05200	N	12:00:00	12:30:00		
05201	N	12:00:00	12:30:00		
05202	N	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211112_F1	**Mission Notes**
Mission	11/12/2021	Flight
Aircraft	CFFRY	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05070	S	12:00:00	12:30:00		
05071	S	12:00:00	12:30:00		
05072	S	12:00:00	12:30:00		
05073	S	12:00:00	12:30:00		
05074	S	12:00:00	12:30:00		
05075	S	12:00:00	12:30:00		
05076	S	12:00:00	12:30:00		
05077	S	12:00:00	12:30:00		
05078	S	12:00:00	12:30:00		
05079	S	12:00:00	12:30:00		
05080	S	12:00:00	12:30:00		
05081	S	12:00:00	12:30:00		
05082	S	12:00:00	12:30:00		
05083	S	12:00:00	12:30:00		
05084	S	12:00:00	12:30:00		
05085	S	12:00:00	12:30:00		
05086	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211112_F2	**Mission Notes**
Mission	11/12/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05171	N	12:00:00	12:30:00		
05172	N	12:00:00	12:30:00		
05173	N	12:00:00	12:30:00		
05174	N	12:00:00	12:30:00		
05175	N	12:00:00	12:30:00		
05176	N	12:00:00	12:30:00		
05177	N	12:00:00	12:30:00		
05178	N	12:00:00	12:30:00		
05179	N	12:00:00	12:30:00		
05180	N	12:00:00	12:30:00		
05181	N	12:00:00	12:30:00		
05182	N	12:00:00	12:30:00		
05183	N	12:00:00	12:30:00		
05184	N	12:00:00	12:30:00		
05185	N	12:00:00	12:30:00		
05186	N	12:00:00	12:30:00		
05187	N	12:00:00	12:30:00		
05188	N	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211114_F1	**Mission Notes**
Mission	11/14/2021	Flight
Aircraft	CFFRY	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05029	S	12:00:00	12:30:00		
05030	S	12:00:00	12:30:00		
05031	S	12:00:00	12:30:00		
05032	S	12:00:00	12:30:00		
05033	S	12:00:00	12:30:00		
05034	S	12:00:00	12:30:00		
05035	S	12:00:00	12:30:00		
05036	S	12:00:00	12:30:00		
05037	S	12:00:00	12:30:00		
05038	S	12:00:00	12:30:00		
05039	S	12:00:00	12:30:00		
05040	S	12:00:00	12:30:00		
05041	S	12:00:00	12:30:00		
05042	S	12:00:00	12:30:00		
05043	S	12:00:00	12:30:00		
05044	S	12:00:00	12:30:00		
05045	S	12:00:00	12:30:00		
05046	S	12:00:00	12:30:00		
05047	S	12:00:00	12:30:00		
05048	S	12:00:00	12:30:00		
05049	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211115_F1	**Mission Notes**
Mission	11/15/2021	Flight
Aircraft	CFFRY	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05054	S	12:00:00	12:30:00		
05055	S	12:00:00	12:30:00		
05056	S	12:00:00	12:30:00		
05057	S	12:00:00	12:30:00		
05058	S	12:00:00	12:30:00		
05059	S	12:00:00	12:30:00		
05060	S	12:00:00	12:30:00		
05061	S	12:00:00	12:30:00		
05062	S	12:00:00	12:30:00		
05063	S	12:00:00	12:30:00		
05064	S	12:00:00	12:30:00		
05065	S	12:00:00	12:30:00		
05066	S	12:00:00	12:30:00		
05067	S	12:00:00	12:30:00		
05068	S	12:00:00	12:30:00		
05069	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211116_F1	**Mission Notes**
Mission	11/16/2021	Flight
Aircraft	CFFRY	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05087	S	12:00:00	12:30:00		
05088	S	12:00:00	12:30:00		
05089	S	12:00:00	12:30:00		
05090	S	12:00:00	12:30:00		
05091	S	12:00:00	12:30:00		
05092	S	12:00:00	12:30:00		
05093	S	12:00:00	12:30:00		
05094	S	12:00:00	12:30:00		
05095	S	12:00:00	12:30:00		
05096	S	12:00:00	12:30:00		
05097	S	12:00:00	12:30:00		
05098	S	12:00:00	12:30:00		
05099	S	12:00:00	12:30:00		
05100	S	12:00:00	12:30:00		
05101	S	12:00:00	12:30:00		
05102	S	12:00:00	12:30:00		
05103	S	12:00:00	12:30:00		
05104	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211116_F2	**Mission Notes**
Mission	11/16/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05050	S	12:00:00	12:30:00		
05051	S	12:00:00	12:30:00		
05052	S	12:00:00	12:30:00		
05053	S	12:00:00	12:30:00		
05126	N	12:00:00	12:30:00		
05127	N	12:00:00	12:30:00		
05128	N	12:00:00	12:30:00		
05129	N	12:00:00	12:30:00		
05130	N	12:00:00	12:30:00		
05131	N	12:00:00	12:30:00		
05212	N	12:00:00	12:30:00		
05228	N	12:00:00	12:30:00		
05229	N	12:00:00	12:30:00		
05230	N	12:00:00	12:30:00		
05231	N	12:00:00	12:30:00		
05232	N	12:00:00	12:30:00		
05233	N	12:00:00	12:30:00		
05234	N	12:00:00	12:30:00		
05235	N	12:00:00	12:30:00		
05236	N	12:00:00	12:30:00		
05237	N	12:00:00	12:30:00		
05238	N	12:00:00	12:30:00		
05239	N	12:00:00	12:30:00		
05240	N	12:00:00	12:30:00		
05241	N	12:00:00	12:30:00		
05242	N	12:00:00	12:30:00		
05243	N	12:00:00	12:30:00		
05244	N	12:00:00	12:30:00		
05279	E	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211117_F1	**Mission Notes**
Mission	11/17/2021	Flight
Aircraft	CFFRY	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05105	S	12:00:00	12:30:00		
05106	S	12:00:00	12:30:00		
05107	S	12:00:00	12:30:00		
05108	S	12:00:00	12:30:00		
05109	S	12:00:00	12:30:00		
05110	S	12:00:00	12:30:00		
05111	S	12:00:00	12:30:00		
05112	S	12:00:00	12:30:00		
05113	S	12:00:00	12:30:00		
05114	S	12:00:00	12:30:00		
05115	S	12:00:00	12:30:00		
05116	S	12:00:00	12:30:00		
05117	S	12:00:00	12:30:00		
05118	S	12:00:00	12:30:00		

Project	947121-R037174.00	AZ_PimaCounty_2021_D21
Flightpla	3232_NV5_Arizona_QL1_BK05	

Mission	Partner_20211117_F2	**Mission Notes**
Mission	11/17/2021	Flight
Aircraft	CGKSX	
Pilot	(Subcontractor)	
Co-Pilot		
Operato	(Subcontractor)	
Co-Oper		
Vendor	Airborne Imaging	
Base Air	NV5 Geospatial	
Departu		
Arrival (I		

Line	Heading	Start Time (UTC)	Stop Time (UTC)	Speed (kt)	Notes
05119	S	12:00:00	12:30:00		
05120	S	12:00:00	12:30:00		
05121	S	12:00:00	12:30:00		
05122	S	12:00:00	12:30:00		
05123	S	12:00:00	12:30:00		
05124	S	12:00:00	12:30:00		
05125	S	12:00:00	12:30:00		
05245	N	12:00:00	12:30:00		
05246	N	12:00:00	12:30:00		
05247	N	12:00:00	12:30:00		
05248	N	12:00:00	12:30:00		
05249	N	12:00:00	12:30:00		
05250	N	12:00:00	12:30:00		
05251	N	12:00:00	12:30:00		
05252	N	12:00:00	12:30:00		
05253	N	12:00:00	12:30:00		
05278	E	12:00:00	12:30:00		
05280	SW	12:00:00	12:30:00		