Contact information

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Project Name: White Sands National Monument, NM.

1. ALTM Specifications

This survey used an Optech GEMINI Airborne Laser Terrain Mapper (ALTM) serial number 06SEN195 mounted in a twin-engine Cessna Skymaster (Tail Number N337P) The instrument nominal specifications are listed in table 1.

Table 1 – Optech Gemini ALTM specifications.

Operating Altitude	80 - 3500 m, Nominal
Horizontal Accuracy	1/5,500 x altitude (m AGL); 1 sigma
Elevation Accuracy	5 - 20 cm; 1 sigma (Height and PRF dependent)
Range Capture	Up to 4 range measurements, including 1st, 2nd, 3rd, last returns
Intensity Capture	12-bit dynamic range for all recorded returns, including last returns
Scan FOV	0 - 50 degrees; Programmable in increments of ±1degree
Scan Frequency	0 – 70 Hz
Scanner Product	Up to Scan angle x Scan frequency = 1000
Roll Compensation	±5 degrees at full FOV – more under reduced FOV
Pulse Rate Frequency	33 - 100 kHz
Position Orientation System	Applanix POS/AV 510 OEM includes embedded BD950 12-channel 10Hz GPS receiver
Laser Wavelength/Class	1064 nanometers / Class IV (FDA 21 CFR)
Beam Divergence nominal (full angle)	Dual Divergence 0.3 mrad (1/e) or 0.80 mrad (1/e)

See http://www.optech.ca for more information from the manufacturer.

2. Survey area

The survey area is a rectangular polygon on the White Sands National Monument, lying west of Holloman Air Force Base NM and enclosing 38.5 square kilometers. The survey location is shown below in Figure 1.
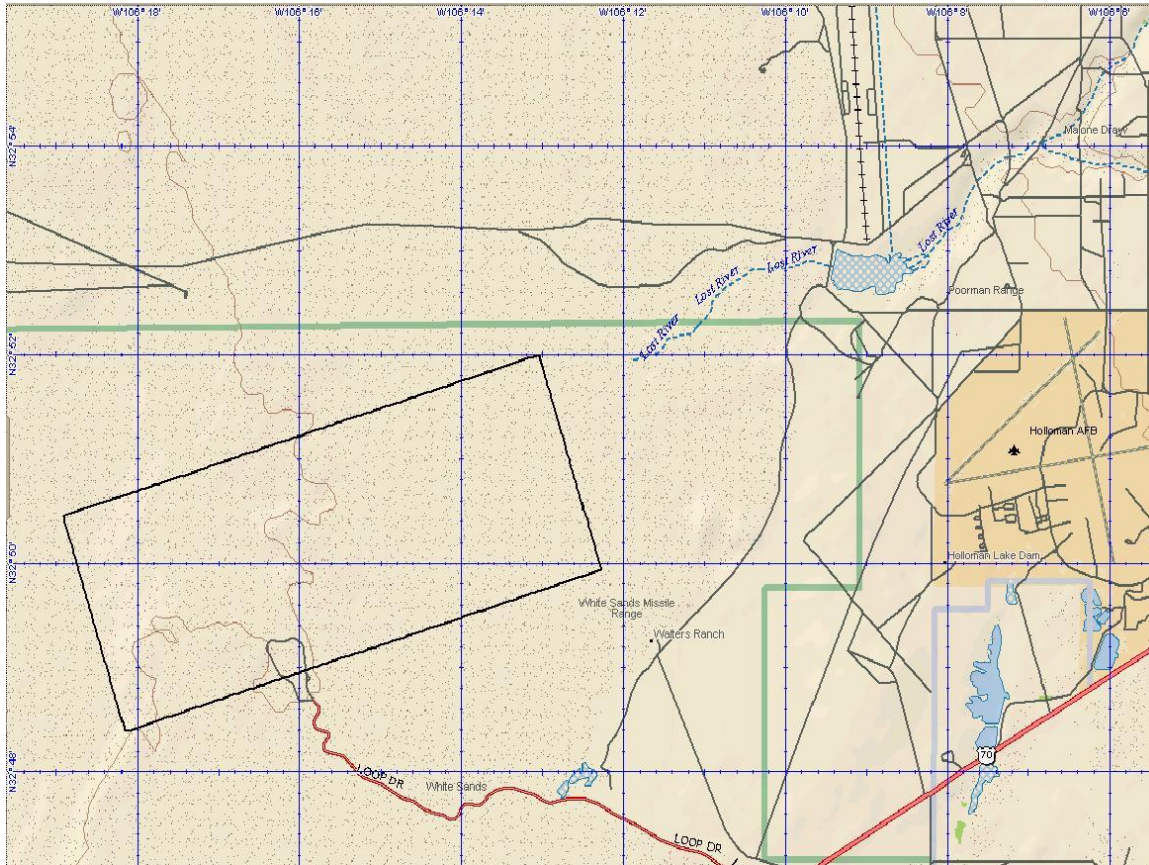

Figure 1 – Size, shape and location of survey polygon.

3. Survey Times
This area was flown in a single survey flight on September 26, 2009; day-of-year 269.

4. Survey Parameters

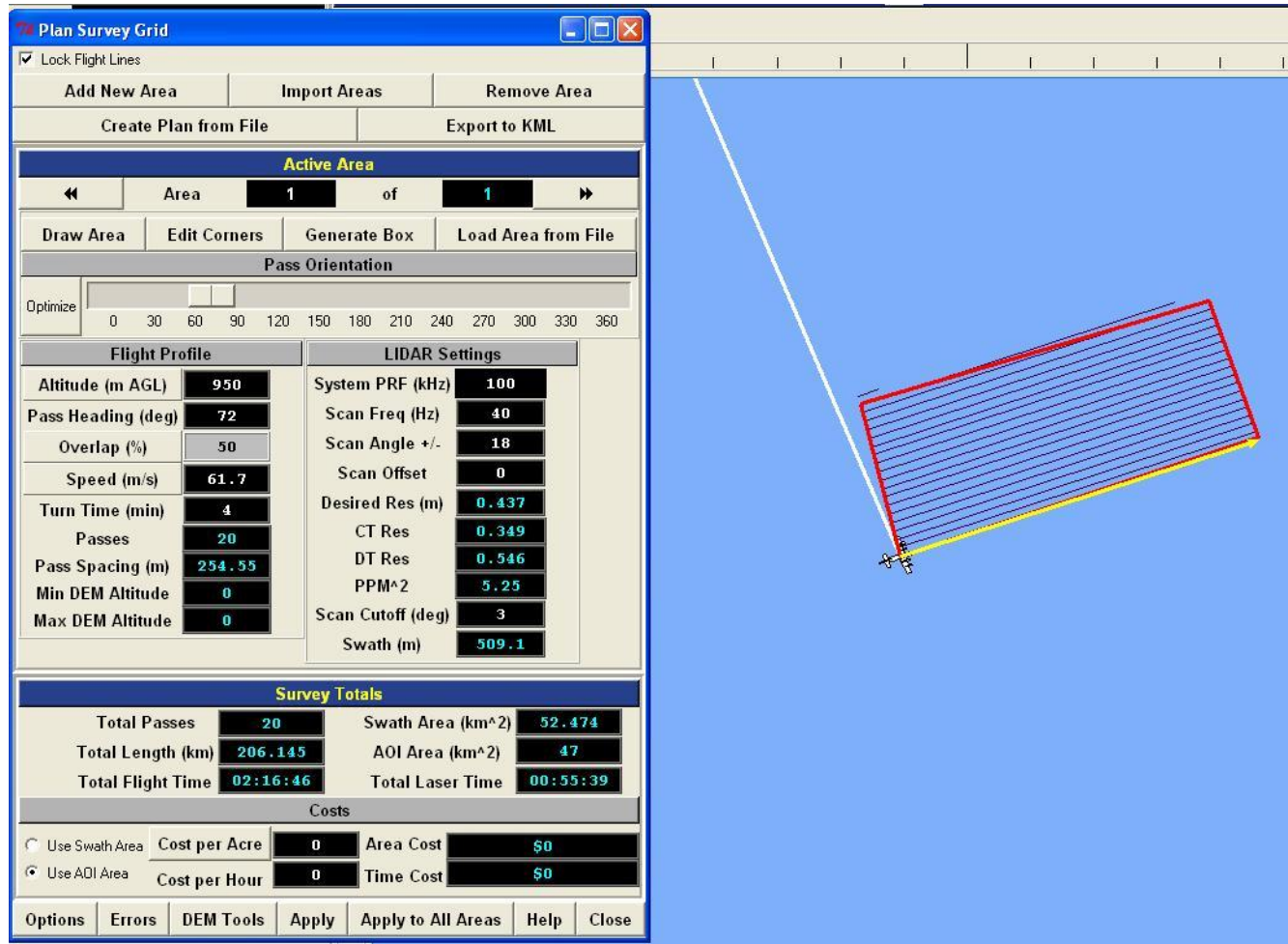The survey required 20 flight lines, shown below in Figure 2.

Figure 2 - Flight lines with planning parameters.

Survey totals appear below in Table 3.

Survey Totals

Total Passes	20
Total Length	206 km
Total Flight Time	02:16:46
Total Laser Time	00:55:39
Total Swath Area	52 km^2
Total AOI Area	47 km^2

Table 3 – Survey totals. Area of Interest is abbreviated AOI.

LiDAR settings are shown in Table 4.

LiDAR Settings	
Desired Resolution	0.437 m
Cross Track Resolution	0.35 m
Down Track Resolution	0.55 m
Scan Frequency	40 Hz
Scan Angle	+/- 18 deg
Scan Cutoff	+/- 3.0 deg
Scan Offset	0 deg
System PRF	100 kHz
Swath Width	509 m

Table 4 – LiDAR settings.

5. GPS Reference Stations

Two GPS reference station locations were used during the survey: ALM_ and HAMP. Station ALM_ was set by the field crew at the Alamogordo White Sands Regional Airport and station HAMP was set on the loop drive at White Sands National Monument. GPS observations at both reference stations were logged at 1 Hz and submitted to the NGS on-line processor OPUS. OPUS processes static differential baselines and provides accurate control coordinates relative to the National CORS network. For further information on the CORS network or OPUS see http://www.ngs.noaa.gov/CORS/ or http://www.ngs.noaa.gov/OPUS/ .

The airborne receiver is an integrated BD-950 Trimble GPS receiver module logging at 10 Hz.

6. Navigation Processing and Calibration

Airplane trajectories for this survey were processed using KARS software (Kinematic and Rapid Static) written by Dr. Gerry Mader of the NGS Research Laboratory. KARS kinematic GPS processing uses the dual-frequency phase history files of the reference and airborne receivers to determine a fixed integer ionosphere-free differential solution. KARS software was used to process kinematic aircraft trajectories from both reference stations

After GPS processing, the 1 Hz differential trajectory and the Inertial Measurement Unit (IMU) data collected during the flight were input into APPLANIX software POSPROC. POSPROC processing algorithms combine GPS positions and IMU orientations in a Kalman Filter to produce a final, smoothed, and complete navigation solution including both aircraft position and orientation at 200 Hz. This final solution is known as the SBET (Smoothed Best Estimated Trajectory).

See http://www.applanix.com/products/posav_index.php for more information from the manufacturer.

The SBET and the raw laser range data were combined using Optech's DashMap processing suite to generate the laser point dataset.

Bore sight calibrations are done by surveying crossing flight-lines with the ALTM over near-by residential neighborhoods and also on the project polygon and using TerraMatch software (http://www.terrasolid.fi/en/products/terramatch) to calculate calibration values. Residential neighborhoods are utilized because building rooftops provide ideal surfaces (exposed, solid, and sloped in different aspects) for automated calibration.

TerraMatch uses least-squares methods to find the best-fit values for roll, pitch, yaw, and scanner mirror scale by analyzing the height differences between computed laser surfaces of rooftops and ground surfaces from individual crossing and/or overlapping flight lines. TerraMatch is generally run on several different areas. TerraMatch routines also provide a measurement for the mismatch in heights of the overlapped portion of adjacent flight strips.

NCALM makes every effort to produce the highest quality LiDAR data possible but every LiDAR point cloud and derived DEM will have visible artifacts if it is examined at a sufficiently fine level. Examples of such artifacts include visible swath edges, corduroy (visible scan lines), and data gaps.

A detailed discussion on the causes of data artifacts and how to recognize them can be found here:

http://ncalm.berkeley.edu/reports/GEM_Rep_2005_01_002.pdf ,
and a discussion of the procedures NCALM uses to ensure data quality can be found here:
http://ncalm.berkeley.edu/reports/NCALM_WhitePaper_v1.2.pdf
NCALM cannot devote the required time to remove all artifacts from data sets, but if researchers find areas with artifacts that impact their applications they should contact NCALM and we will assist them in removing the artifacts to the extent possible – but this may well involve the PIs devoting additional time and resources to this process.

7. Laser Point Processing

All coordinates were processed with respect to NAD83 and referenced to the national CORS network. The projection is UTM Zone 13, with units in meters. Heights are NAVD88 orthometric heights computed using NGS GEOID03 model. Figure 7 (below) are tile footprints on shaded relief image.
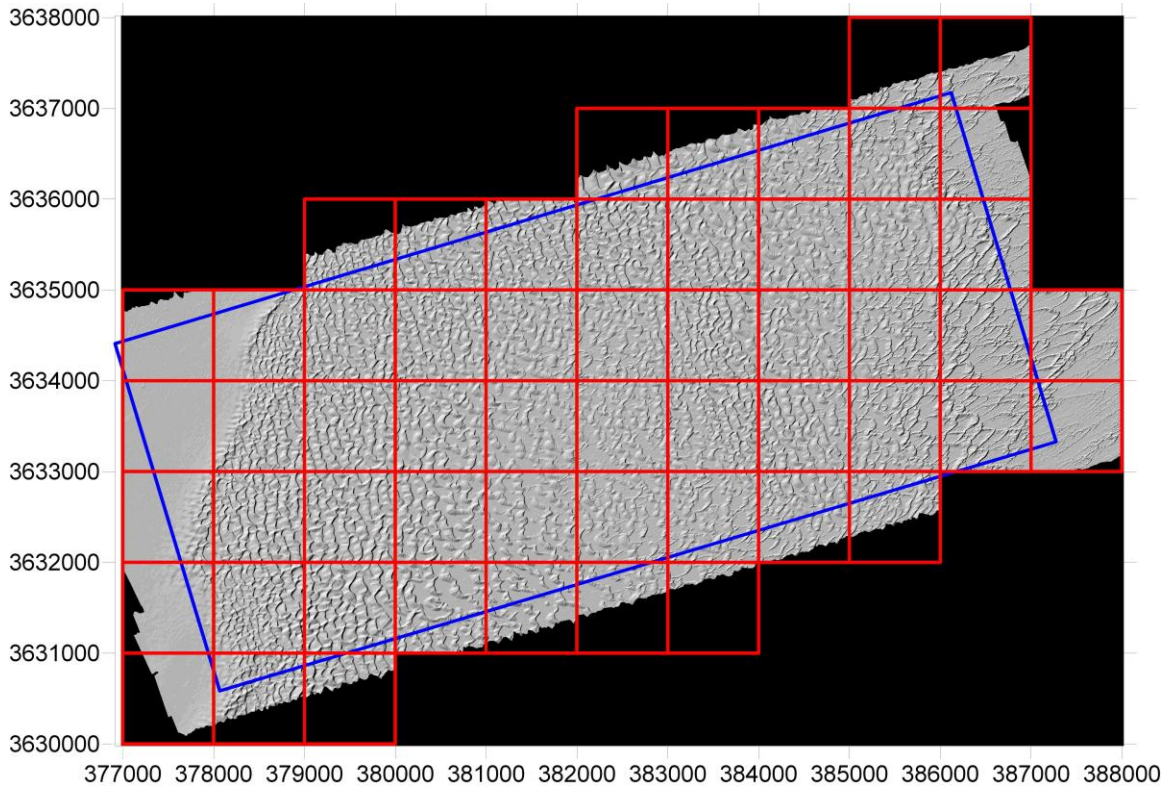

Figure 7 - Tile footprints overlaid onto a shaded relief image of the DEM. Tile foot prints are in red, the survey polygon is in blue.

These tile footprints are available as an AutoCAD DXF or ESRI shape file. The project totaled 56 tiles and is ASCII format with three columns: Easting, Northing, and NAVD88 elevation.

During processing, a scan cutoff angle of 3.0 degrees was used to eliminate points at the edge of the scan lines. This was done to improve the overall DEM accuracy as points farthest from the scan nadir are the most affected by small errors in pitch, roll and scanner mirror angle measurements.

8. Deliverables Description

All deliverables were processed with respect to NAD83 (CORS96) reference frame. The projection is UTM zone 13N with units in meters. Heights are NAVD88 orthometric heights computed from GRS80 ellipsoid heights using NGS GEOID03 model.

Deliverable 1 is the point cloud in LAS format, classified by automated routines in TerraScan (http://www.terrasolid.fi/en/products/terrascan) as ground or non-ground in tiles created from the combined flight strips. The flight strip point cloud files were tiled into 1 kilometer square blocks with a naming convention using the lower left coordinate (minimum X, Y) as the seed for the file name as follows: XXXXXX_YYYYYYY. For example if the tile bounds coordinate values from easting equals 379000 through 380000, and northing equals 3631000 through 3632000 then the tile filename is 379000_3631000.

Deliverable 2 is the ESRI format DEM mosaic derived from deliverable 1 using default-class (first-stop) points at 1 meter node spacing. Elevation rasters are first created using Golden Software's Surfer 8 Kriging algorithm. The following parameters are used:

```
Gridding Algorithm: Kriging
Variogram: Linear
Nugget Variance: 0.15 m
MicroVariance: 0.00 m
SearchDataPerSector: 7
SearchMinData: 5
SearchMaxEmpty: 1
SearchRadius: 5m
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The resulting Surfer grids are transformed into ArcInfo binary DEMs and hill shades using in-house Python and AML scripts.

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