LiDAR Survey of a portion of the Dune Fields in White Sands National Monument, Utah
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1. LiDAR System Description and Specifications

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

Operating Altitude	150-4000 m, Nominal
Horizontal Accuracy	1/5,500 x altitude (m AGL); 1 sigma
Elevation Accuracy	5 - 35 cm; 1 sigma
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 - 167 kHz
Position Orientation System	Applanix POS/AV 510 OEM includes embedded BD950 72-channel 10Hz GPS receiver
Laser Wavelength/Class	1047 nanometers / Class IV (FDA 21 CFR)
Beam Divergence nominal (full angle)	Dual Divergence 0.25 mrad (1/e) or 0.80 mrad (1/e)

Table 1 – Optech GEMINI specifications (http://www.optech.ca/pdf/Gemini_SpecSheet_100908_Web.pdf).

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

2. Area of Interest.

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.
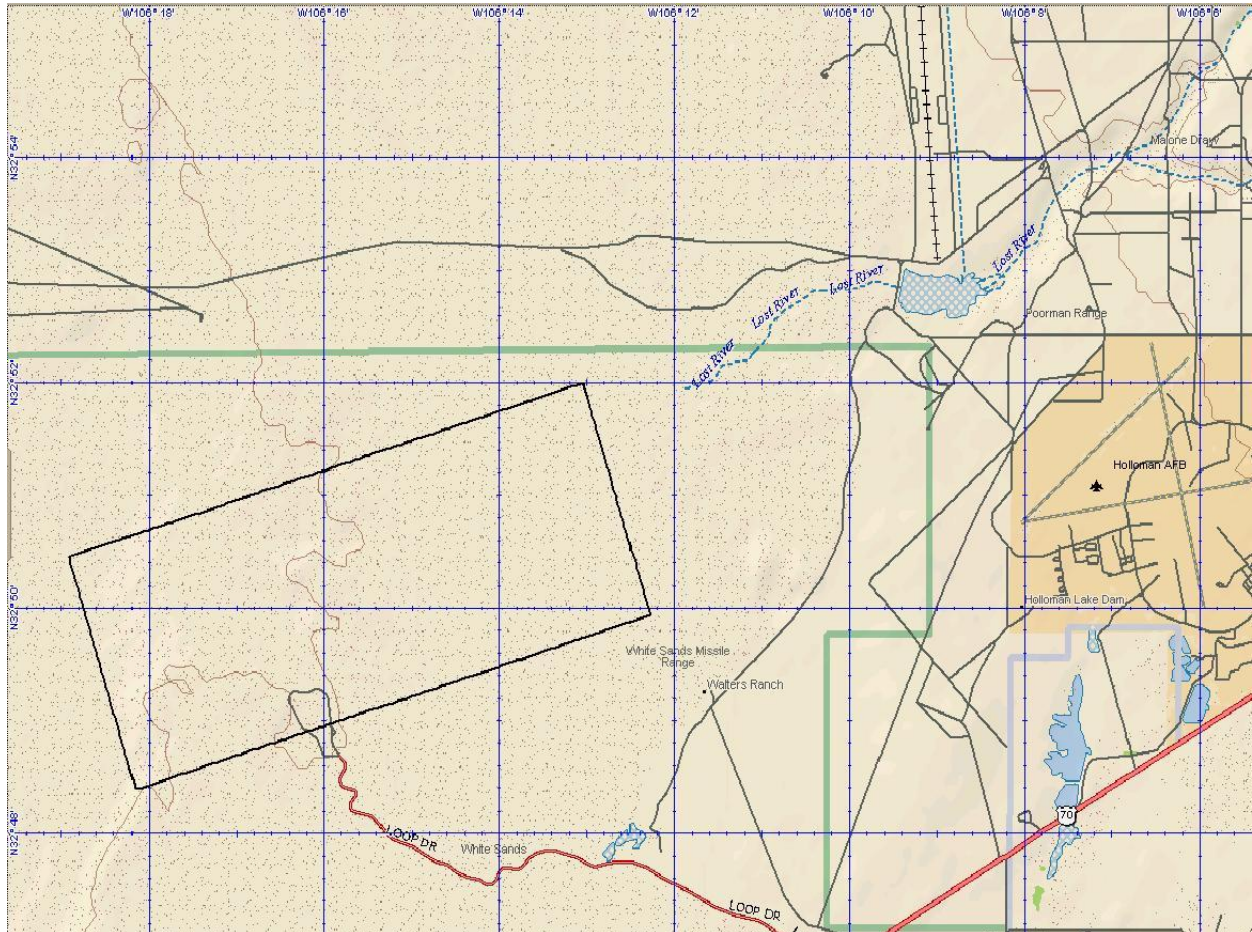

Figure 1 – Shape and location of survey polygon (Delorme Topo Software).

3. Data Collection

a) **Survey Dates**: The survey took place on January 24, 2009 (DOY 024).

b) **Airborne Survey Parameters:** The survey parameters are provided in Table 2 below

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	950 m	Laser PRF	100 kHz	Total Flight Time	2.6 hrs
Flight Speed	61.7 m/s	Beam Divergence	0.25 mrad	Total Laser Time	0.9 hrs
Swath Width	508 m	Scan Frequency	40 Hz	Total Swath Area	52.5 km^2
Swath Overlap	50%	Scan Angle	± 20°	Total AOI Area	47 km^2
Point Density	5.25 p/m²	Scan Cutoff	3°		

Table2 – Survey Parameters and Totals.

Ground GPS: Two GPS reference station locations were used during the survey: KALM and SAND. Station KALM was set by the field crew at the Alamogordo White Sands Regional Airport and station SAND was set on the grounds of White Sands National Monument. GPS observations at both reference stations were logged at 1 Hz.

GPS station	KALM	SAND
Operating agency	NCALM	NCALM
Latitude	32.83950871	32.81893169
Longitude	-105.9956077	-106.2741963
Ellipsoid Height (m)	1244.722	1185.234

Table 3 – GPS Coordinates of ground reference stations

4. GPS/IMU Data Processing

Reference coordinates for all stations are derived from observation sessions taken over the project duration and submitted to the NGS on-line processor OPUS which processes static differential baselines tied to the international CORS network. For further information on OPUS see http://www.ngs.noaa.gov/OPUS/ and for more information on the CORS network see http://www.ngs.noaa.gov/CORS/

Airplane trajectories for this survey were processed using KARS (Kinematic and Rapid Static) software written by Dr. Gerald 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 high-accuracy fixed integer ionosphere-free differential solution at 1 Hz. All final aircraft trajectories for this project are blended solutions from the two stations.

After GPS processing, the trajectory solution and the raw inertial measurement unit (IMU) data collected during the flights are combined in APPLANIX software POSPac Version 4.3. POSPac implements a Kalman Filter algorithm to produce a final, smoothed, and complete navigation solution including both aircraft position and orientation at 200 Hz. This final navigation solution is known as an SBET (Smoothed Best Estimated Trajectory).

5. LiDAR Data Processing Overview

The following diagram (Figure 2) shows a general overview of the NCALM LiDAR data processing workflow
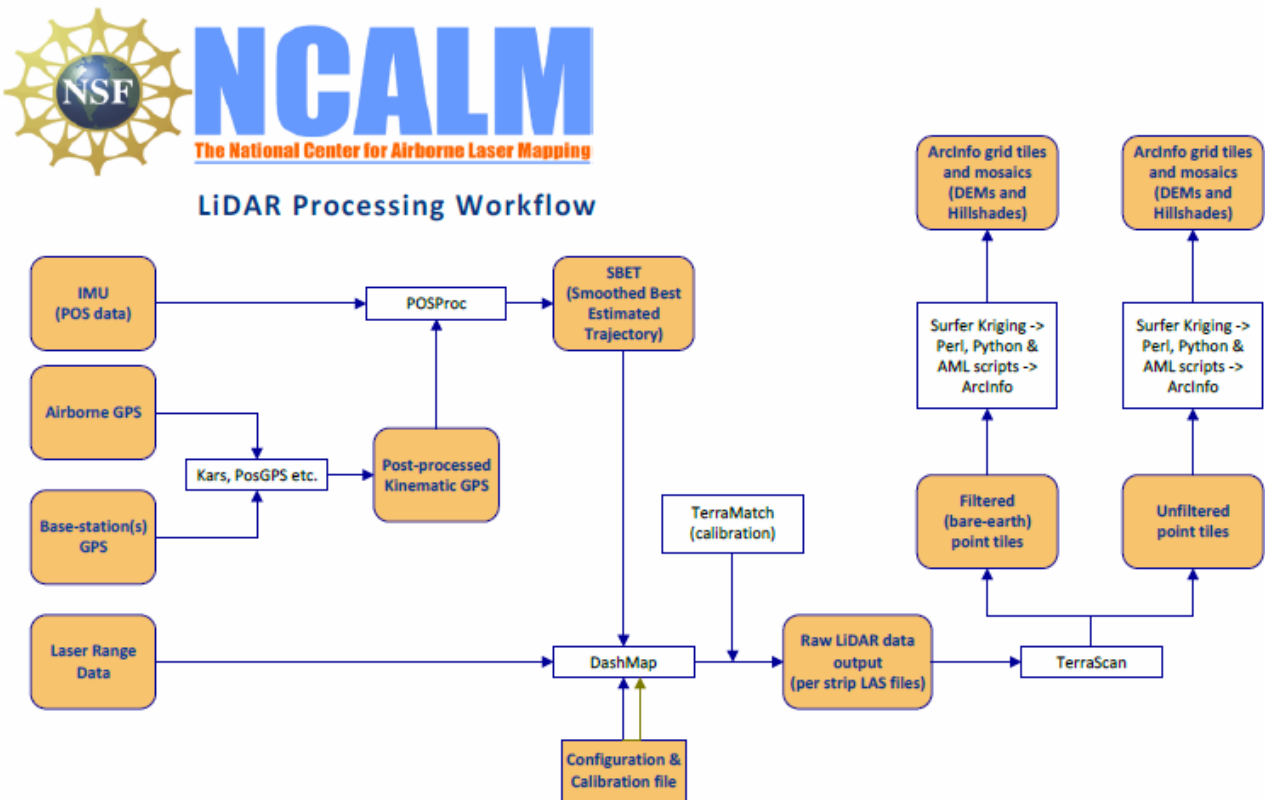

Figure 2 NCALM LiDAR Processing Workflow

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 .

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.

6. Accuracy Assessment

Eight hundred eight-one check points were collected by vehicle-mounted GPS at the Alamogordo airport and then surveyed with the ALTM at the start of the survey flight. The RMS of the height differences between these check points and their nearest neighbor LiDAR point was 0.041 meters.

7. Data Deliverables

a) **Horizontal Datum**: NAD83 (CORS96)
b) **Vertical Datum:** NAVD88 (GEOID 03)
c) **Projection:** UTM Zone 13N
d) **File Formats:**

1. Point Cloud in LAS format, all points in default class, 1 km square tiles.
2. ESRI format 1-m DEM from default-class points.
3. ESRI format 1-m Hillshade raster from default- class points

e) **File naming convention:** 1 Km tiles follow 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 3635000 through 3636000 then the tile filename incorporates 379000_3635000. These tile footprints are available as an AutoCAD DXF or ESRI shapefile. The ESRI DEMs are single mosaic files created by combining together the 1KM tiles. Their name consists of prefix 'fme' or 'ume' (depending whether the DEM is made using ground points or all points) and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'fme379000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'fme379000sh'.

8. Notes

Point classification was not done on these data per PI request; all points remain in their default point class.