LiDAR Survey Project Report

Applying ALSM to scale up rainfall interception before and after removal of pinon and juniper in a woodland-encroached sagebrush ecosystem

Project executed for PI: Devon Snyder

University of Nevada, Reno Department of Natural Resources and Environmental Science	e-mail: devonsnyder@cabnr.unr.edu Phone: 484-844-0764 Fax: 775-784-1375

1. LiDAR System Description and Specifications

This survey was performed with an Optech Gemini Airborne Laser Terrain Mapper (ALTM) LiDAR serial number 06SEN195 mounted in a twin-engine Piper Chieftain PA-31 with Tail Number N154WW. 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 BD960 72-channel 10Hz (GPS+GLONASS) receiver
Laser Wavelength/Class	1064 nanometers / Class IV (FDA 21 CFR)
Beam Divergence nominal (full angle)	Dual Divergence 0.25 mrad (1/e) or 0.80 mrad (1/e)

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

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

2. Areas of Interest.

The survey area consisted of a polygon located about 180kms east of Carson City, Nevada. The polygon is approximately 6.5 km on each side, enclosing approximately 42 km². The polygon layout and location are shown with red outline below in Figure 1.

Figure 1 – Shape and location of survey polygon (Google Earth).

3. Data Collection

a) Survey Dates: The survey flight took place on July 14, 2015, DOY 195. The airport that served as the base of operation for the flights was Carson City Airport (KCXP). The total flight time was 3.5 hrs. with a total laser on time of 1.2 hrs.

b) Airborne Survey Parameters: The nominal survey parameters are provided in Table 3 below.

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	600 m	Laser PRF	100 kHz	Total Flight Time	3.5 hrs
Flight Speed	65 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.2 hrs
Swath Width	390 m	Scan Frequency	40 Hz	Total Swath Area	60 km^2
Swath Overlap	50 %	Scan Angle	± 18°	Total AOI Area	42 km^2
Point Density	7 p/m²	Scan Cutoff	2.0°		

Table 2 – Survey Parameters and Totals.

c) **Ground GPS:** Four GPS reference station locations were used during the survey, which are part of UNAVCO's PBO network. All reference GPS observations were logged at 1 Hz. Table 3 gives the coordinates of the stations and Figure 2 shows the project area and the reference GPS station locations.

GPS station	P136	P134	P130	P133
Agency	UNAVCO	UNAVCO	UNAVCO	UNAVCO
Latitude	38.76136	38.98087	39.26803	38.7326
Longitude	-119.45851	-118.9304	-118.93774	-118.4602
Height	1773.84	1886.57	1380.65	1782.41

Table 3 – GPS Coordinates of ground reference stations. Ellipsoid height (NAD83) in meters.

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 four 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 MMS (Mobile Mapping Suite Version 7.1). POSPac MMS 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

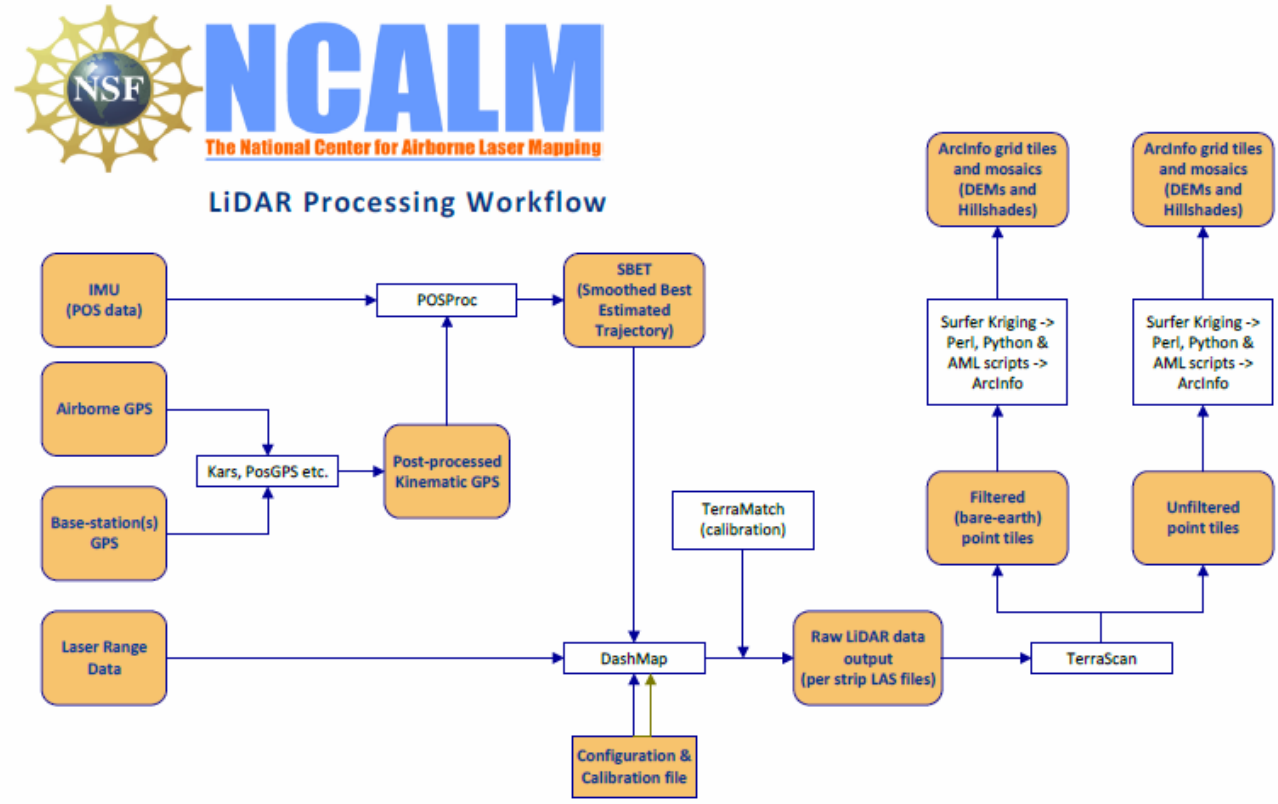

Figure 2 NCALM LiDAR Processing Workflow

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.

Classification done by automated means using TerraSolid Software
http://www.terrasolid.fi/en/products/4

6. Data Deliverables

a) **Horizontal Datum**: NAD83
b) **Vertical Datum:** NAVD88 (Geoid 12A)
c) **Projection:** UTM Zone 11N
d) **File Formats:**

1. Point Cloud in LAS format, points classified as ground and non-ground, in 1 km square tiles.
2. ESRI format 1-m DEM from first-return points.
3. ESRI format 1-m bare earth DEM from ground classified points only.
4. ESRI format 1-m Hillshade raster from First-return points.
5. ESRI format 1-m bare earth Hillshade raster from ground classified points only.

e) **File naming convention:** 1 Km LAS 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 447000 through 448000, and northing equals 4368000 through 4369000 then the tile filename incorporates 447000_4368000. 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.