LiDAR Survey Project Report

Investigating Triggers for Channel Avulsion on Alluvial Fans

Project executed for PI: Alexander Morgan

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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.

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

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.

2. Areas of Interest.

The survey area consisted of a polygon located in California 49 km east of Bishop. The polygon is approximately 10 km long by 3.5 km wide and encloses approximately 35 km². The polygon layout and location are shown with red outline below in Figure 1.

Figure 1 – Shape and location of survey polygon and the GPS base stations (Google Earth).

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3. Data Collection

a) **Survey Dates**: The survey flight took place on July 1, 2015, DOY 182. The airport that served as based of operation for the flights was East Sierra Regional airport (KBIH) at Bishop. Detail flight information for the flight is included on Table 2 below.

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	4.0 hrs
Flight Speed	65 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.5 hrs
Swath Width	321 m	Scan Frequency	60 Hz	Total Swath Area	49 km^2
Swath Overlap	50 %	Scan Angle	± 15°	Total AOI Area	35 km^2
Point Density	8 p/m²	Scan Cutoff	1.0°		

Table2 – Survey Parameters and Totals.

c) **Ground GPS:** Three GPS reference station locations were used during the survey: all 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 1 shows the project area and the reference GPS station locations.

GPS station	P094	P469	P726
Agency	UNAVCO	UNAVCO	UNAVCO
Latitude	37.2008	37.2314	37.2805
Longitude	-117.7041	-117.9357	-118.1466
Height	1729.87	1795.47	2202.13

Table 3 – GPS Coordinates of ground reference stations. Ellipsoid height (NAD 83) 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 three 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 (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
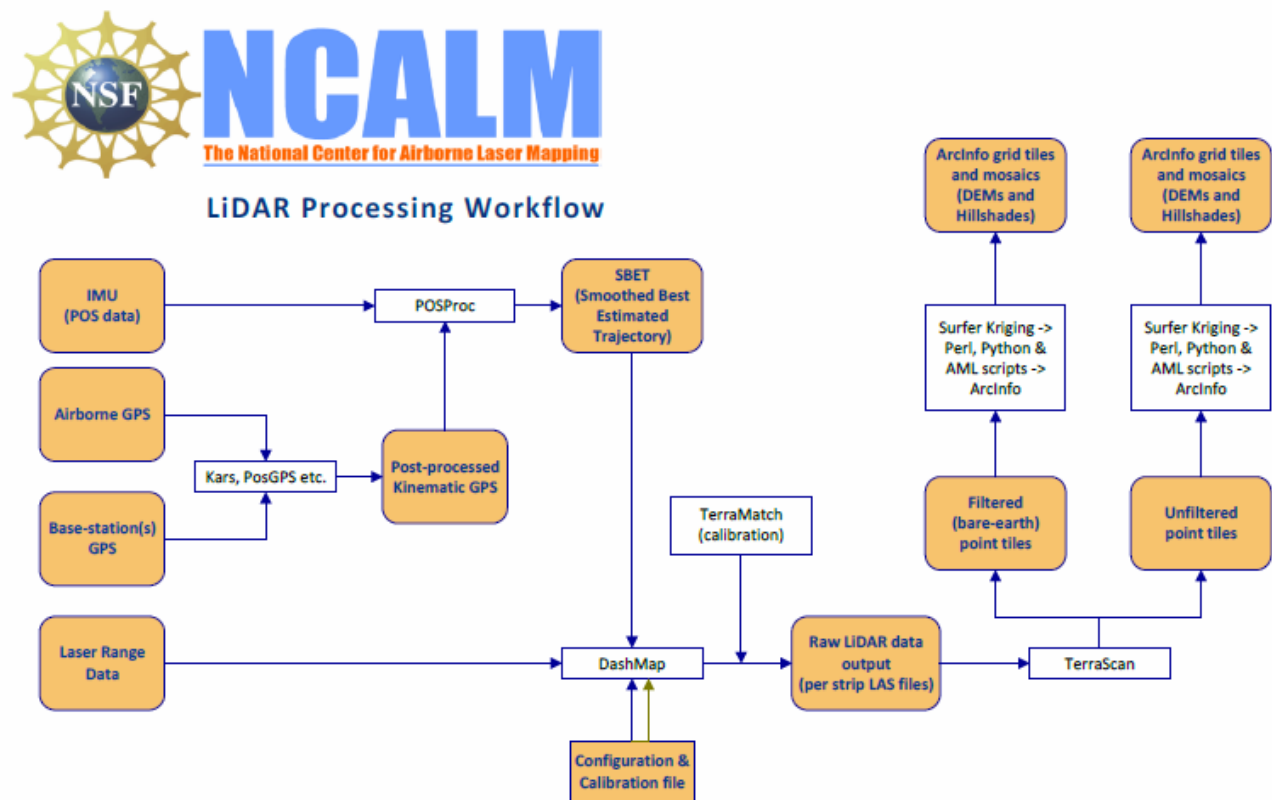

Figure 2 NCALM LiDAR Processing Workflow

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 was 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 (Geoid12A)
c) **Projection:** UTM Zone 11N
d) **File Formats:**

1. Point Cloud in LAS format, all points in default class, in 1 km square tiles.
2. ESRI format 1-m DEM from all points.
3. ESRI format 1-m Hillshade raster from all 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_YYYYYY. For example if the tile bounds coordinate values from easting equals 555000 through 556000, and northing equals 3843000 through 3844000 then the tile filename incorporates 555000_3843000. 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.

7. Notes

Point classification was not done as there is no vegetation; all points were classified into ground class.