LIDAR Data Collection and processing report

Controls on Magma Ascent and Eruption at a Mafic Intraplate Volcanic Field, Lunar Crater Volcanic Field

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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 06SEN/CON195 mounted in a twin-engine Piper Navajo Chieftain (Tail Number N31PR) aircraft. 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 and Glonass) receiver
Laser Wavelength/Class	1054 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/gemini.htm).

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

2. Area of Interest.

The survey area is defined by a rectangular polygon located in Nevada, about 110Km east of Tonopah. The polygon dimensions are approximately 33km x 11.2 km, with a planned surface area of 366.64 km². The location and extent of the polygon are shown below in Figure 1.

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

3. Data Collection

a) Survey Dates: The survey took place from June 30, 2012 through July 3, 2012 (DOY 183 to 186). The plan consisted of 72 project lines running Northeast to Southwest along the length of the rectangular polygon. Two additional lines, as shown in Figure 1, perpendicular to the project lines were added to the plan to perform system and data calibration. The Tonopah Airport(KTPH) was used as base for this mission.

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

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	600m AGL	Laser PRF	125 kHz	Total Flight Time	17.67 hrs
Flight Speed	60 m/s	Beam Divergence	0.25 mrad	Total Laser Time	11.25 hrs
Swath Width	320 m	Scan Frequency	45 Hz	Total Swath Area	390 km^2
Swath Overlap	50%	Scan Angle	± 17°	Total AOI Area	373 km^2
Point Density	11.3 p/m^2	Scan Cutoff	1°		

Table2 – Survey Parameters and Totals.

c) Ground GPS: Three GPS reference station locations were used during the survey. One GPS station, TONO, is part of the UNAVCO PBO GPS network (see http://pbo.unavco.org/data/gps) and other two, GPS1 and GPS2 were set up by NCALM. Observations were logged at 1 Hz. Table 3 gives the coordinates of the stations, and Figure 3 shows the location of the GPS stations with respect to the project area.

GPS station	**TONO**	**GPS1**	**GPS2**
Operating agency	UNAVCO	NCALM	NCALM
Latitude	38.097194	38.066278	38.196991
Longitude	-117.18404	-117.09683	-116.31362
Ellipsoid Height (m)	2066.022	1630.022	1579.912

Table 3 – GPS Coordinates of ground reference stations

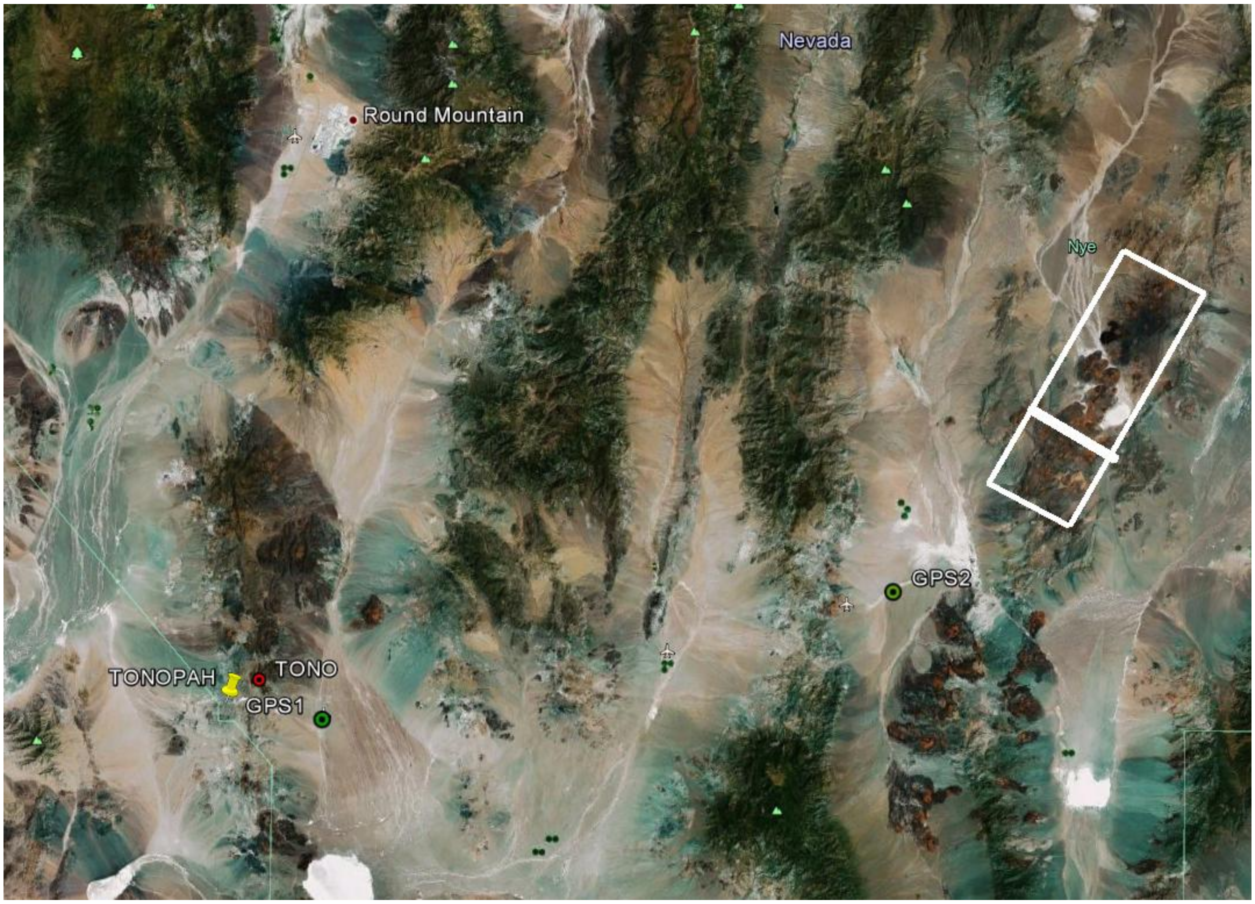

Figure 3 – Location of the GPS Stations used in the survey (Google Earth).

4. GPS/IMU Data Processing

Reference coordinates for all NCALM 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 (Mobile Mapping Suite Version 5.2). 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 4) shows a general overview of the NCALM LiDAR data processing workflow

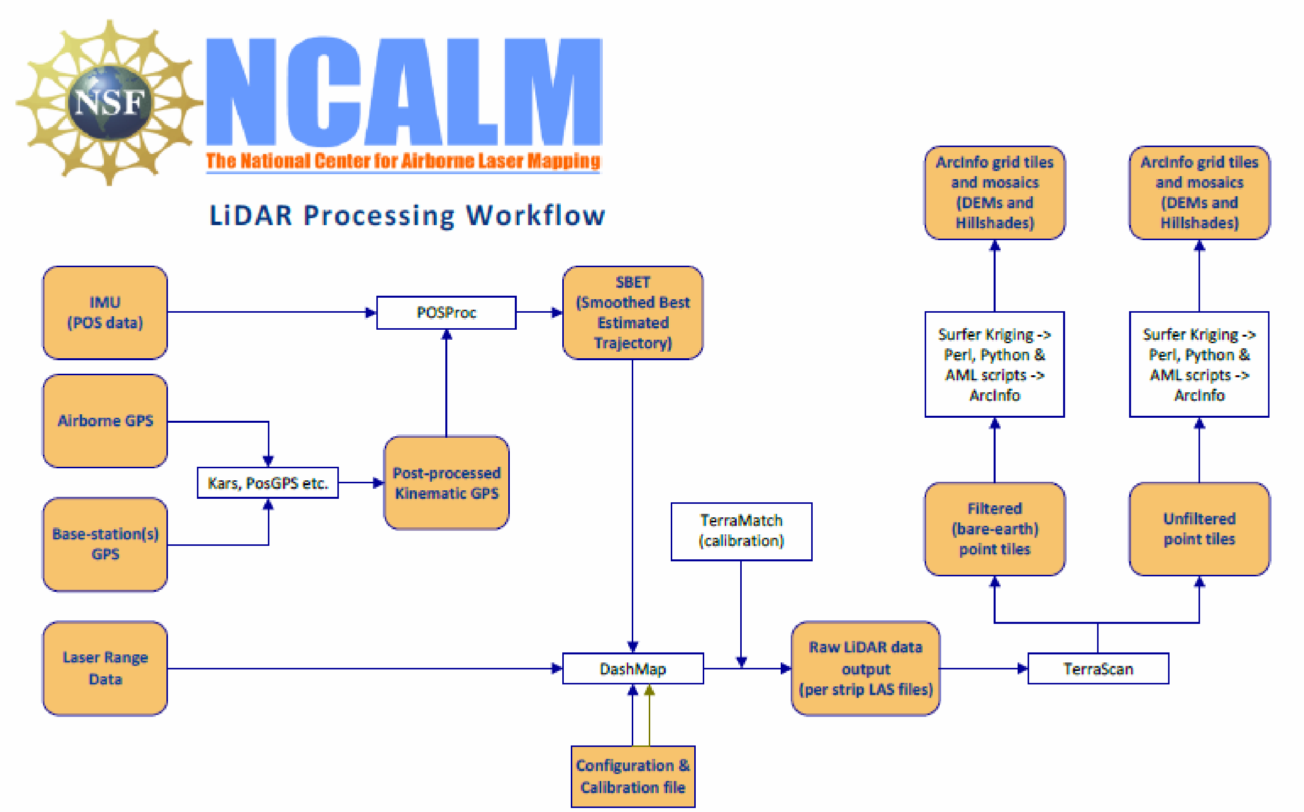

Figure 4 NCALM LiDAR Processing Workflow

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 – removal of outliers only.
http://www.terrasolid.fi/en/products/4

6. Data Deliverables

a) **Horizontal Datum**: NAD83(2011)
b) **Vertical Datum:** GEOID 12
c) **Projection:** UTM Zone 11N
d) **File Formats:**

1. Point Cloud in LAS format in 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
4. ESRI format 1-m DEM from ground-class points
5. ESRI format 1-m Hillshade from ground 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: cXXXXXX_YYYYYYY. For example if the tile bounds coordinate values from easting equals 588000 through 589000, and northing equals 4266000 through 4267000 then the tile filename incorporates c588000_4266000. 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 'ume' (indicating that the DEM is made using default-class points) and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'ume588000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'ume588000sh'.