Data Collection and processing report for the project:

"LiDAR Survey of Surprise Valley, CA"

Principal Investigator: Anne E. Egger, Ph.D.

School of Earth Sciences Stanford University 450 Serra Mall, Building 320, Room 112 Stanford, CA 94305-2115.	E-mail: annegger@stanford.edu Phone: 650-724-0984

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 Cessna Skymaster aircraft (Tail number 337P) and a Piper Chieftain aircraft (Tail number N31PR). The Skymaster operated only on the first day of the survey (June 6, 2012) and was then replaced by the Chieftain due to a mechanical problem.

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 4 irregular polygons located 38 kilometers east of Alturas, CA and including the town of Cedarville, CA. The 4 combined polygon dimensions are approximately 55 x 16 km, with an enclosed area of 797 km². The location and extent of the polygons are shown below in Figure 1.

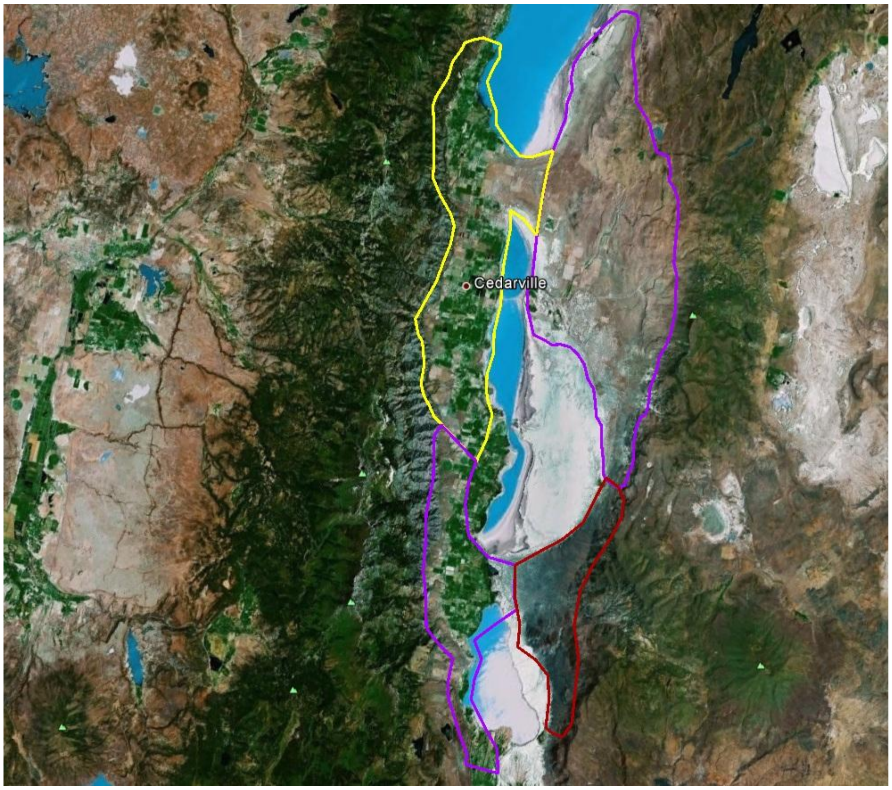

Figure 1 – Shape and location of the 4 survey polygons (Google Earth).

3. Data Collection

a) **Survey Dates**: The survey took place on June 6-14, 2012 (DOY 158-166) following plan file: Egger_SurpriseValley_V2.pln. The plan consisted of 190 project lines running north to south as well as cross lines flown for calibration purposes. The Alturas Airport (KAAT) 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	43.3 hrs
Flight Speed	60 m/s	Beam Divergence	0.25 mrad	Total Laser Time	25.15 hrs
Swath Width	344 m	Scan Frequency	55 Hz	Total Swath Area	874 km^2
Swath Overlap	50%	Scan Angle	± 17°	Total AOI Area	797 km^2
Point Density	~12 p/m^2	Scan Cutoff	1°		

Table 2 – Survey Parameters and Totals.

c) Ground GPS: Three GPS reference station locations were used during the survey; one of these was run by NCALM at the Alturas airport (KAAT) and the other two are administered by UNAVCO as part of the PBO network. See http://pbo.unavco.org/ for more information on the UNAVCO PBO network. Observations from all three stations 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	KAAT	P017	P731
Operating agency	NCALM	UNAVCO	UNAVCO
Latitude	41.48507	41. 27589	41.33251
Longitude	-120.56360	-119.93550	-120.47276
Ellipsoid Height (m)	1310.845	2391.153	1391.795

Table 3 – GPS Coordinates of ground reference stations

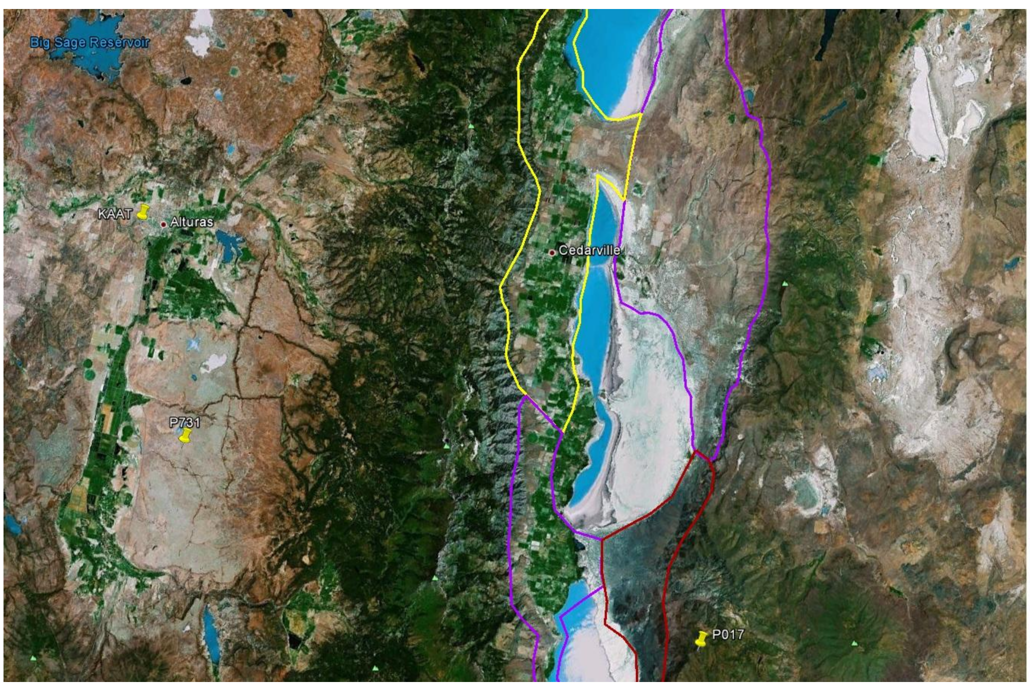

Figure 3. Location of the GPS reference Stations with respect to the project area.

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

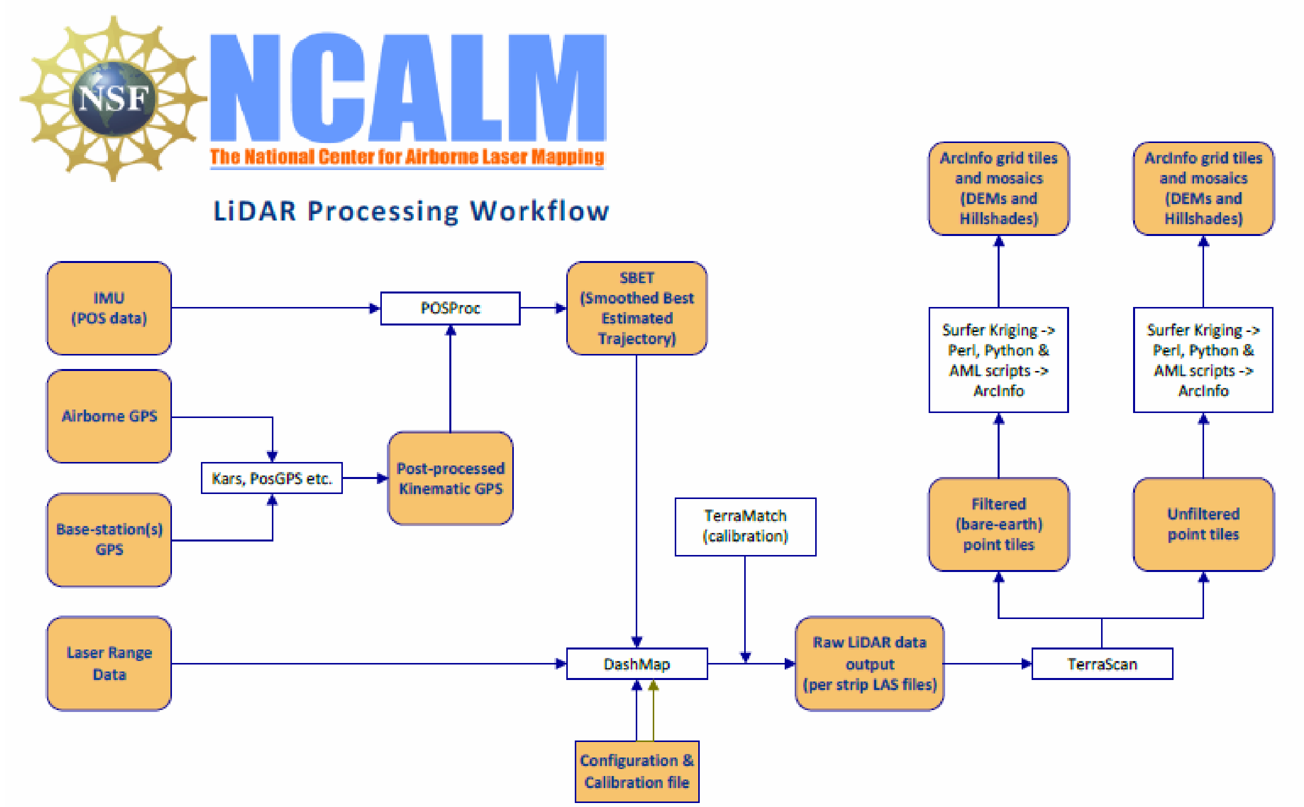

Figure 4 NCALM LiDAR Processing Workflow

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 09
c) **Projection:** UTM Zone 10N
d) **File Formats:**

1. Point Cloud in LAS 1.2 format, classified as ground or non-ground in 1 km square tiles.
2. ESRI format 0.5-m DEM from default-class points.
3. ESRI format 0.5-m Hillshade raster from default-class points
4. ESRI format 0.5-m DEM from ground-class points.
5. ESRI format 0.5-m Hillshade raster 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: XXXXXX_YYYYYYY. For example if the tile bounds coordinate values from easting equals 733000 through 734000, and northing equals 4615000 through 4616000 then the tile filename incorporates 733000_4615000. These tile footprints are available as an AutoCAD DXF or ESRI shapefile. The ESRI DEMs are composed of three mosaic files for each type due to their exceptionally large size. Their names consists of prefix ‘ume’ (‘u’ indicating that the DEM is made using default-class points, ‘f’ indicating ground-class points) and the lowest Easting coordinate rounded to the nearest 1000, for e.g. ‘ume731000’. The hillshade files have a prefix ‘sh’ after the name, for e.g. ‘ume731000sh’.

7. Notes

Grid spacing for the DEMs was set at 0.5 m per PI request.

Accuracy assessments on these data were performed by comparing bare-earth surfaces created from individual flight lines in the zones where these surfaces overlapped both in the project area and over a separate calibration site in Alturas. The average height difference between the surfaces of adjacent flight lines was between 0.035 and 0.065 m.