Data Collection and Processing Report for 2013 SEED Project:
Impacts of valley alluviation on hillslope-channel coupling in the Gabilan Mesa, California

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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 337 Skymaster (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 BD960 72-channel 10Hz (GPS) 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)

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 requested survey area is an irregular polygon located 10 km east of King City, California in the Wildhorse Valley of the Gabilan Mesa. The polygon at its widest point is approximately 13 km long by 5 km high and encloses approximately 52 square km. Figure 1 (below) is an image from Google Earth showing the shape and location of the survey.

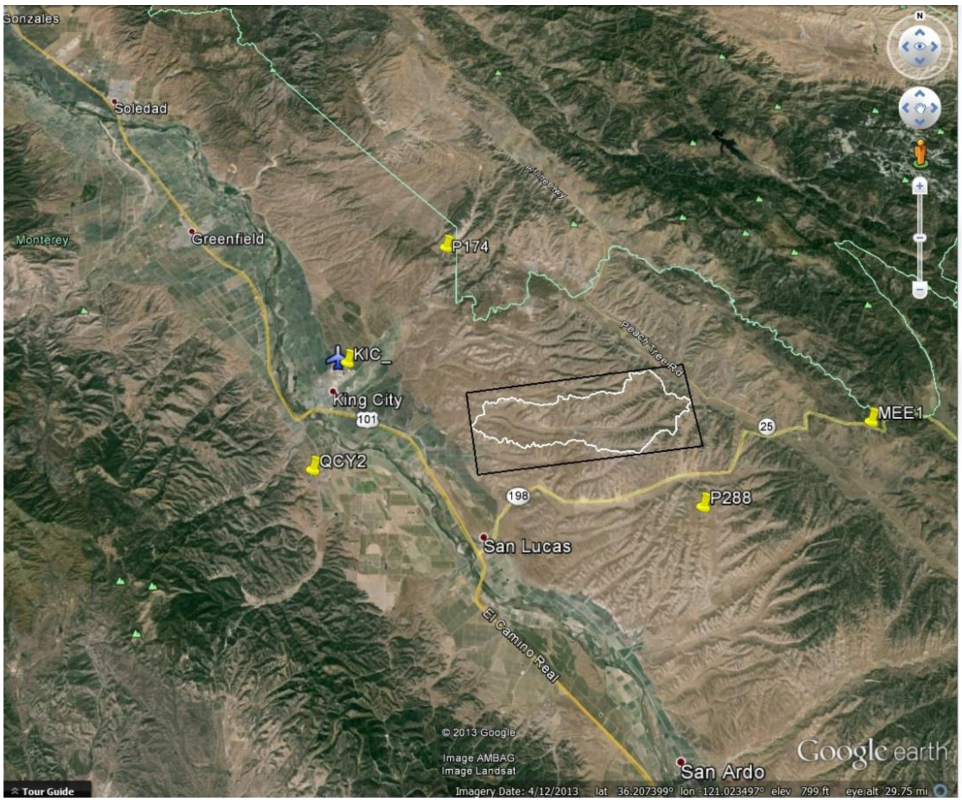

Figure 1 – Shape and location of survey polygon in white. GPS reference station locations are shown as yellow push pins. (Google Earth).

3. Data Collection

3.1 Survey Dates.

The survey took place on August 11, 2013 (DOY 223).

3.2 Airborne Survey Parameters.

Survey parameters are provided in Table 2 below.

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	600 m	Laser PRF	100 kHz	Total Flight Time	2.5 hrs.
Flight Speed	+/- 60 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.2 hrs.
Swath Width	460.6 m	Scan Frequency	40 Hz	Total Swath Area	57.6 km^2
Swath Overlap	Min 50 %	Scan Angle	± 24°	Total AOI Area	52 km^2
Point Density	5.9 p/m²	Scan Cutoff	3.0°	Pass spacing	230 m

Table 2 – Nominal flight parameters, equipment settings and survey totals; actual parameters vary with the terrain.

3.3 GPS Reference Stations

Five GPS reference station locations were used during the survey: four of them belong to UNAVCO's PBO network (see http://pbo.unavco.org/ for more information from UNAVCO) and the remaining one (KIC_) was established by NCALM at operational airport. All GPS reference observations were logged with dual-frequency geodetic-quality receivers and antennas at 1 Hz.

Table 3 (below) gives the coordinates of the stations; refer above to Figure 1 for the relationship of the project area to the GPS reference station locations.

GPS station	MEE1	P174	P288	QCY2	KIC_
Agency	UNAVCO	UNAVCO	UNAVCO	UNAVCO	NCALM
Latitude	36.1869	36.3021	36.1402	36.1611	36.2257
W Longitude	120.7586	121.0509	120.8789	121.1373	121.1192
Height	789.879	342.705	398.311	102.019	80.663

Table 3 – Coordinates of GPS reference stations in NAD83 (2011) Epoch 2010.0000 – GRS80 ellipsoid height in meters.

4. GPS/IMU Data Processing

Control coordinates (NAD83 (2011) Epoch 2010.0000) for all GPS reference 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 all three reference stations.

After GPS processing, the 1 Hz trajectory solution and the 200 Hz 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 3) shows a general overview of the NCALM LiDAR data processing workflow

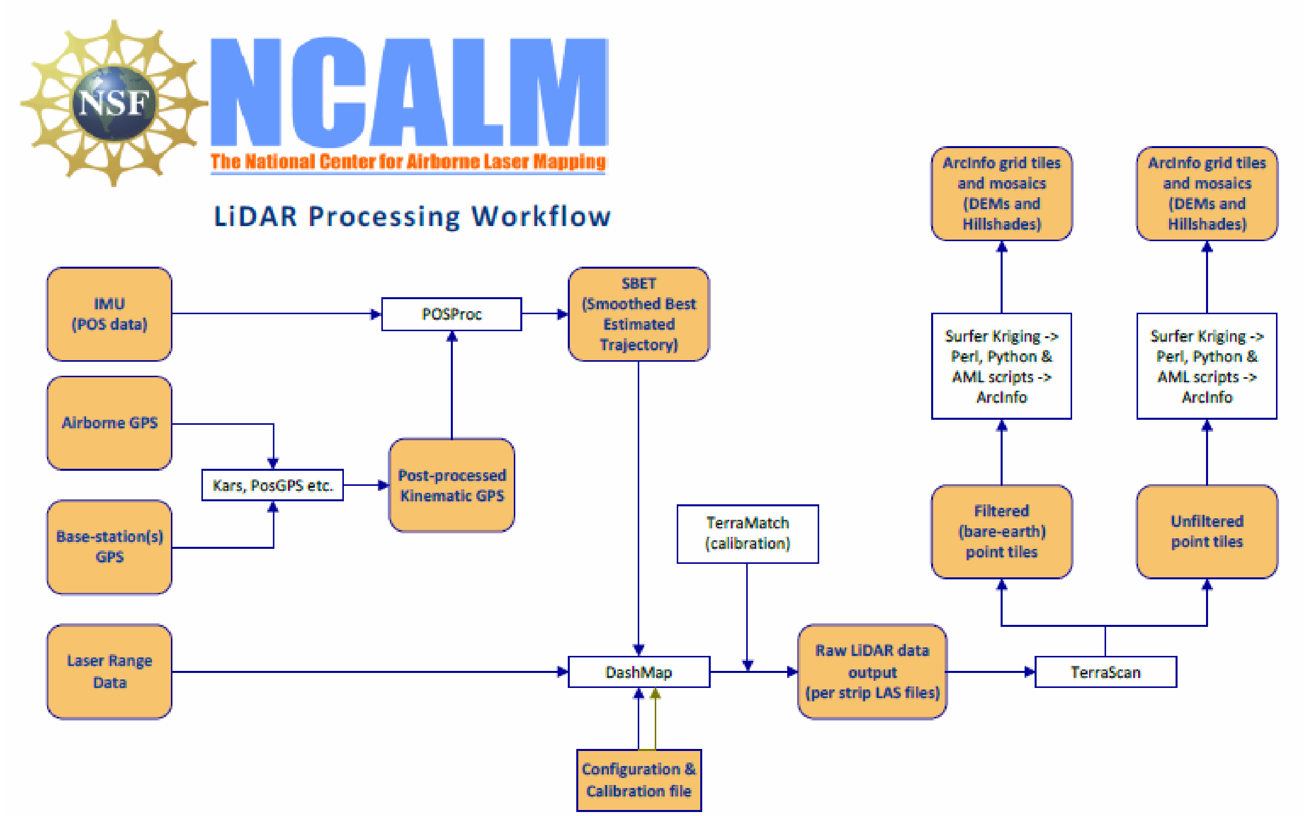

Figure 3 - NCALM LiDAR Processing Workflow

Classification of the ground points used to produce the bare-earth DEM was done by automated means using TerraSolid Software (TerraScan Version 13.015).
http://www.terrasolid.com/home.php

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. Calibration and Accuracy Assessment

6.1 Calibration

System calibration of the 3 sensor bore sight angles (roll, pitch, and yaw) and scanner mirror scale factor is done by automated means using TerraSolid Software (TerraMatch). Project lines and off-project lines flown with opposite headings combined with perpendicular cross lines are used as input to TerraMatch (Version 13.006). The calibration values are checked on a flight-flight basis.

6.2 Relative accuracy

To assess the relative accuracy of individual flight lines, surfaces are created from the ground-class points on a line by line basis and then the elevation mismatch between flight line surfaces in overlap areas is calculated over the entire project area. For this project the average elevation mismatch between individual flight lines is 0.072 meters.

Line	Points	Magnitude	Dz	Line	Points	Magnitude	Dz
7	33942767	0.068	0.001	108	32462648	0.068	0.003
9	35416016	0.085	0.000	16	29979745	0.073	0.004
11	35955697	0.075	0.002	6	30970652	0.072	0.003
13	33603635	0.072	-0.004	8	28979555	0.063	0.000
104	32647464	0.070	-0.001	105	26048899	0.061	-0.005
106	34272579	0.084	-0.003	10	22546613	0.069	0.007
3	17591255	0.077	-0.005	107	20129687	0.065	-0.005
5	34943880	0.082	-0.003	12	16367738	0.066	0.002
14	25260886	0.078	0.005	109	14959566	0.062	-0.004
15	32093878	0.073	0.003	110	10319153	0.075	-0.001
103	31148320	0.065	0.001	111	6270358	0.062	0.003
4	34237939	0.078	-0.001	112	16969024	0.066	-0.001

Table 4 – Flight line elevation mismatch by flight line. Dz refers to the average of the signed differences between flight line surface elevations; Magnitude is the average of the unsigned differences.

6.3 Absolute Accuracy

No ground check points were collected for this project so it is possible that a small (<0.15m) vertical bias in the elevations of the final point cloud and DEM may exist with respect to NAVD88. Note that any LiDAR-derived DEM accuracy will usually degrade on steep terrain and under canopy.

7. Data Deliverables

7.1 Horizontal Datum: NAD83 (2011)

7.2 Vertical Datum: NAVD88 (GEOID 12a)

7.3 Projection: UTM Zone 10N – meters.

7.4 File Formats:

7.4.1 Point Cloud in LAS format (Version 1.2), classified as ground or non-ground, in 1 km square tiles.

7.4.2 ESRI format 1-m DEM from ground classified points.

7.4.3 ESRI format 1-m Hill shade raster from ground classified points.

7.4.4 ESRI format 1-m DEM from all points (canopy included).

7.4.5 ESRI format 1-m Hill shade raster from all points (canopy included).

7.5 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 491000 through 492000, and northing values are 4276000 through 4277000 then the tile filename incorporates 491000_4276000.

These tile footprints are available as an AutoCAD DXF or ESRI shapefile. The ESRI DEMs are single mosaic files created by combining together the 1 km tiles.