



## ALSM Mapping of Sierra Nevada near Oroville, CA

Principal Investigator: Kyungsoo Yoo

University of Delaware Department of Plant and Soil Science	e-mail: <a href="mailto:kyoo@udel.rdu">kyoo@udel.rdu</a>
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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 09SEN195 mounted in a twin-engine Piper Navajo (Tail Number N59984). The instrument nominal specifications are listed in table 1.

Operating Altitude	80- 3500 m, Nominal
Horizontal Accuracy	1/5,500 x altitude (m AGL); 1 sigma
Elevation Accuracy	5 - 30 cm; 1 sigma
Range Capture	Up to 4 range measurements, including 1 <sup>st</sup> , 2 <sup>nd</sup> , 3 <sup>rd</sup> , 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 BD950 12-channel 10Hz GPS receiver
Laser Wavelength/Class	1047 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/Gemini167.pdf>).**

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

## 2. Areas of Interest.

The survey area consisted of a polygon located 15 km Northeast of Lake Oroville, California. The survey location is shown below in Figure 1.

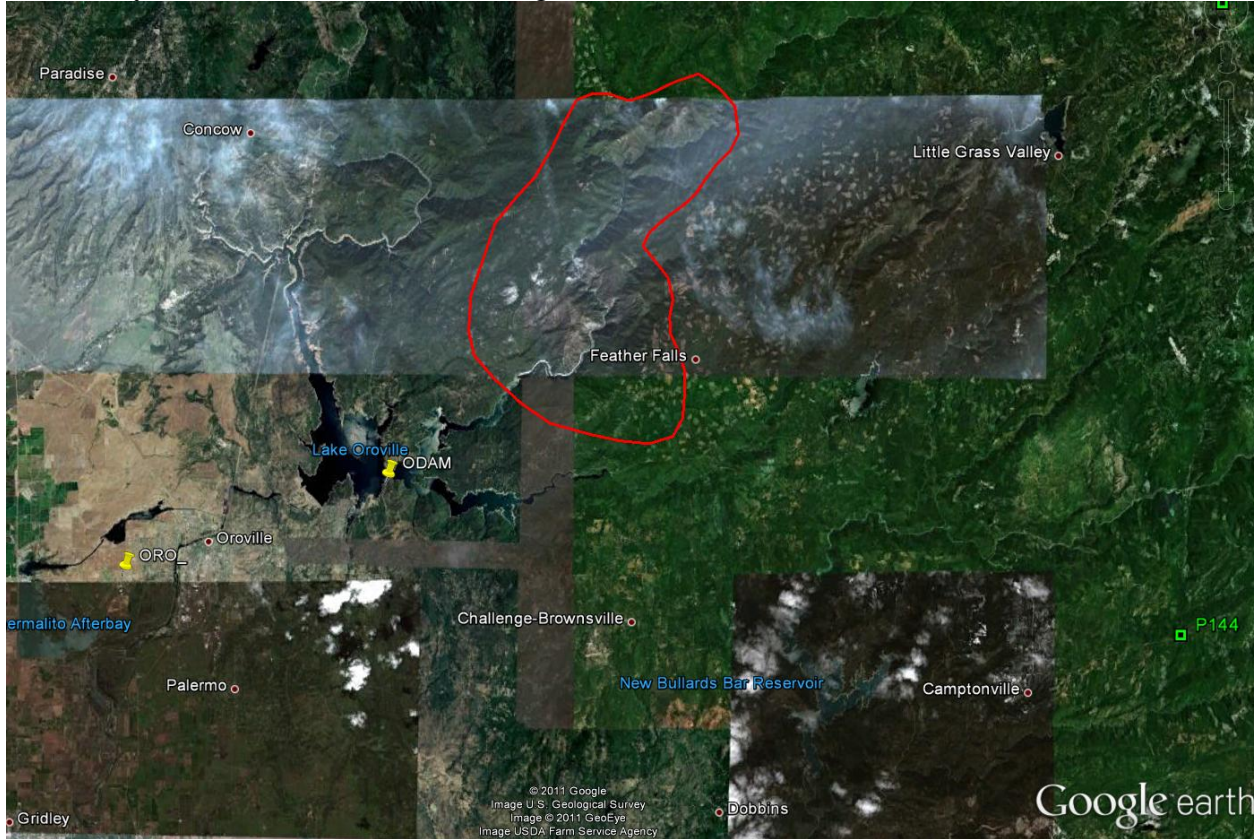


Figure 1 – Shape and location of survey polygon (Google Earth).

## 3. Data Collection

- a) **Survey Date:** Survey was completed in three flights over three days i.e. September 25 - 27, 2008 (DOY 269 -271).
- b) **Airborne Survey Parameters:** The survey parameters are provided in Table 2 below

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	700 m	Laser PRF	70 kHz	Total Passes	96
Flight Speed	60 m/s	Beam Divergence	0.25 mrad	Total Flight Time	16.5 hrs
Swath Width	148.8 m	Scan Frequency	40 Hz	Total Laser Time	11.3 hrs
Swath Overlap	50%	Scan Angle	$\pm 15^\circ$	Total Swath Area	225 km <sup>2</sup>
Point Density	9 p/m <sup>2</sup>	Scan Cutoff	3°	Total AOI Area	208 km <sup>2</sup>

Table 2 – Survey Parameters and Totals.

### c) Ground GPS

Three GPS reference station locations were used during the survey; ODAM and ORO\_ setup by NCALM; and P144 part of the UNAVCO network. All reference GPS observations were logged at 1 Hz. Table 3 gives the coordinates of the stations.

<b>GPS station</b>	<b>ODAM</b>	<b>ORO_</b>	<b>P144</b>
Operating agency	NCALM	NCALM	UNAVCO
Latitude	39.54536	39.49569	39.46669
Longitude	-121.43404	-121.61594	-120.89297
Ellipsoid Height (m)	282.31	32.53	1437.42

**Table 3 – GPS Coordinates of ground reference stations**

## 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.

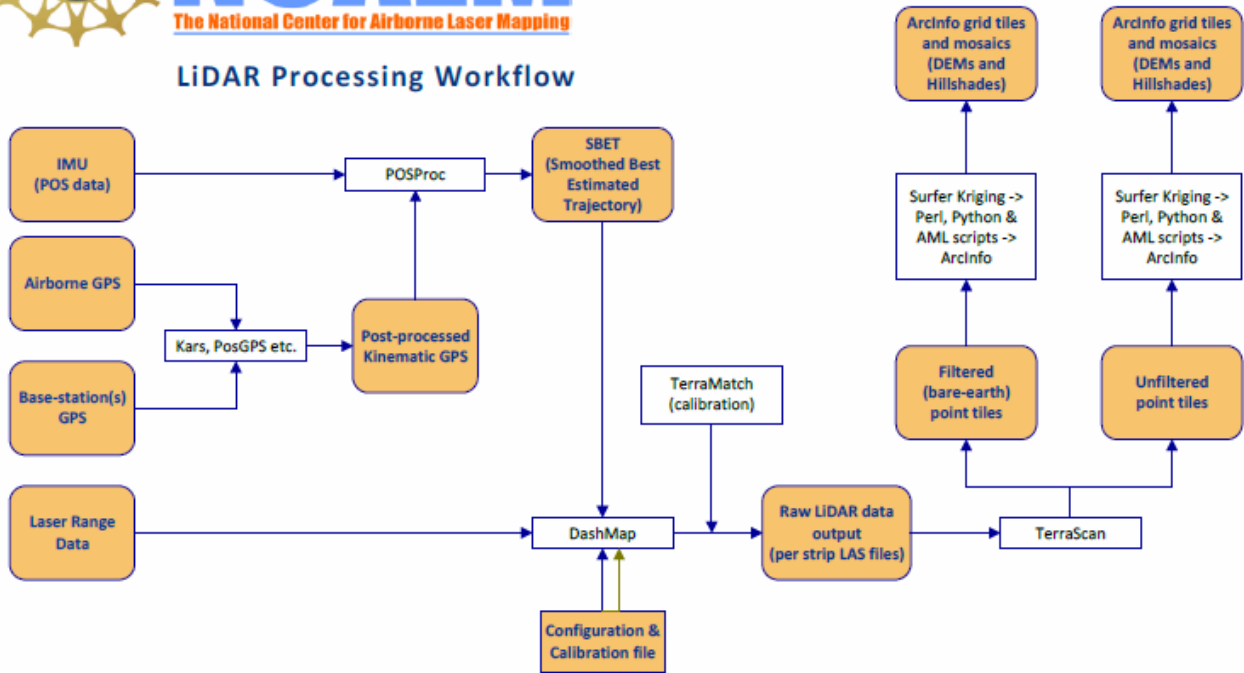
After GPS processing, the trajectory solution and the raw inertial measurement unit (IMU) data collected during the flights are combined in APPLANIX software POSpac MMS (Mobile Mapping Suite Version 5.2). POSpac MMS implements a Kalman Filter algorithm to produce a final, smoothed, and complete navigation 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 2) shows a general overview of the NCALM LiDAR data processing workflow



### LiDAR 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](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](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(CORS96)
- b) **Vertical Datum:** NAVD 88, GEOID 03
- c) **Projection:** UTM Zone 10N
- d) **File Formats:**
  - 1. Point Cloud in LAS format, classified as ground or non-ground, in 1 km square tiles.
  - 2. ESRI format 1-m DEM from ground classified points.
  - 3. ESRI format 1-m Hillshade raster from ground classified points
  - 4. ESRI format 1-m DEM from all points (canopy included).
  - 5. ESRI format 1-m Hillshade raster from all points (canopy included).
- 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 385000 through 38600, and northing equals 4288000 through 4289000 then the tile filename incorporates 385000\_4288000. These tile footprints are available as an AutoCAD DXF or ESRI shape file. The ESRI DEMs are mosaic files created by combining together the 1KM tiles. Their name consists of prefix 'fme' and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'fme385000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'fme385000sh'. These tiles are 10KM along in X direction.