Analysis of South Fork Eel River Watershed Morphology
(June 27 – 30, 2004)

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0. Abstract

This is a LiDAR derived bare-earth digital elevation model of the Heath & Marjorie Angelo Coast Range Reserve and South Fork Eel River watershed to the confluence with Tenmile Creek. Heath and Marjorie Angelo Coast Range Reserve is owned and administered as an ecological preserve and research area by UC Berkeley Reserve System (http://nrs.ucop.edu). Previously owned and operated by the Nature Conservancy.

1. LiDAR System Description and Specifications

This survey was performed with an Optech 2033 Airborne Laser Terrain Mapper (ALTM) serial number 98b110 mounted in a twin-engine Cessna 337 Skymaster aircraft (Tail Number N337P). The instrument nominal specifications are listed in table 1.

Operating Altitude	330 - 2000 meters
Range Accuracy	10 cm single shot
Range Resolution	1 cm
Relative Accuracy	5-10 cm @ 33KHz
Options	Intensity data; First and Last Pulse Measurements; Extended Altitude (2 Km)
Scan Angle	Variable from 0 to +/- 20
Angle accuracy	0.05 degrees
Angle Resolution	0.01 degrees
Scan Frequency	Variable - product of scan rate and scan frequency must be <590
Pulse Rate Frequency	33 KHz
Roll and Pitch Accuracy	0.04 degrees
Heading Accuracy	0.05 degrees
Laser Wavelength	1047 nanometers
Beam Divergence	0.30 mrad

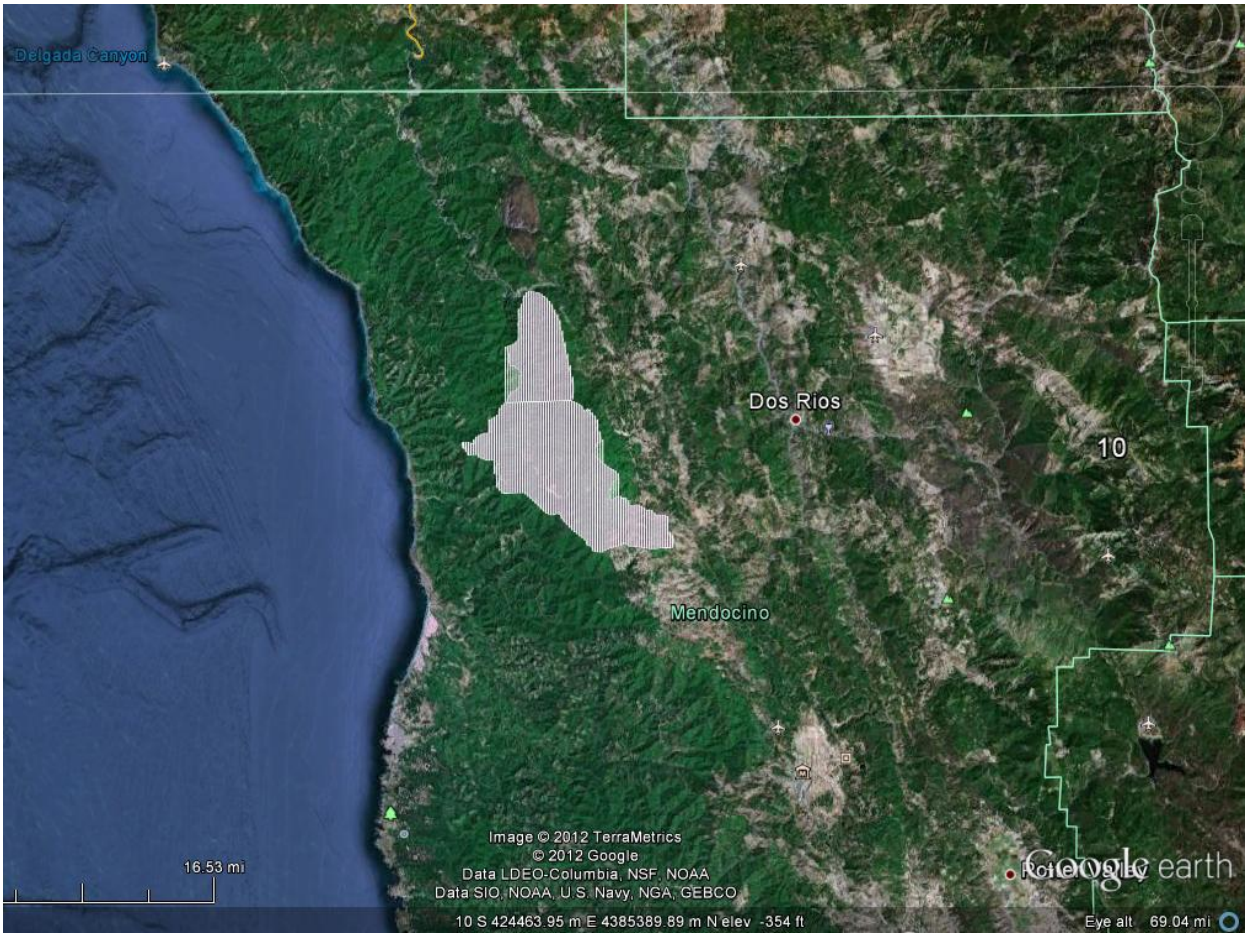
Table 1 – Optech ALTM 2033 specifications.

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

2. Area of Interest.

The survey area consisted of a polygon located 20 Km East of Dos Rios in 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 Dates: The survey took place over eight flights from 6/27/2004 – 6/30/2004 (DOY 179- 182).

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

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	600 m	Laser PRF	33.3 kHz	Total Flight Time	22.7 hrs
Flight Speed	60 m/s	Beam Divergence	0.30 mrad	Total Laser Time	4.5 hrs
Swath Width	436 m	Scan Frequency	28 Hz	Total Swath Area	203 km^2
Swath Overlap	50%	Scan Angle	± 20°	Total AOI Area	189 km^2
Point Density	1.25 p/m^2	Scan Cutoff	2°		

Table 2 – Survey Parameters and Totals.

c) Ground GPS: Three GPS reference station locations were used during the survey: CDOT, EEL1 and WILB. All of the reference stations collected GPS observations at 1 Hz. Table 3 gives the coordinates of the stations.

GPS station	CDOT	EEL1	WILB
Operating agency	NCALM	NCALM	NCALM
Latitude	39 50 26.30892	39 40 28.65710	39 27 6.05718
Longitude	123 42 10.58850	123 47 26.90786	123 22 23.56558
Ellipsoid Height (m)	297.189	-9.867	595.923

Table 3 – GPS Coordinates of ground reference stations

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 all stations.

After GPS processing, the trajectory solution and the raw inertial measurement unit (IMU) data collected during the flights are combined in APPLANIX software POSProc. POSProc implements a Kalman Filter algorithm to produce a final, smoothed, and complete navigation

solution including both aircraft position and orientation at 50 Hz. This final navigation solution is known as an SBET (Smoothed Best Estimated Trajectory).

5. LiDAR Data Processing Overview

LiDAR point-cloud processing was done in Optech REALM software, ASCII is the only supported output format.

Calibration of roll, pitch, and scanner mirror scale was done manually using cross-lines flown perpendicular to project lines.

Classification of the point cloud into two classes – ground and non-ground_ was performed by automated routines using software developed by researchers at the UF and by Optech software.

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. Accuracy Assessment

None performed.

7. Data Deliverables

a) **Horizontal Datum**: NAD83(CORS96)
b) **Vertical Datum:** GRS80 (no GEOID model has been applied)
c) **Projection:** UTM Zone 10N
d) **File Formats:**

1. Point cloud data in ASCII format (XYZ), classified as ground or non-ground, in 1 km square tiles.
2. ESRI format 1-m DEM and Hillshade raster from ground classified points.
3. ESRI format 1-m DEM and Hillshade raster from all points (canopy included).