Data Collection and Processing Report for 2013 SEED Project:
Morphological and Soil Chemistry Signatures of Transient Landscape Evolution in the Oregon Coast Range

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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. Areas of Interest.

The requested survey area consisted of a polygon located 60 Km West of Eugene, Oregon. The polygon encloses approximately 42 square km. Figure 1 (below) is an image from Google Earth showing the shape and location of the survey.
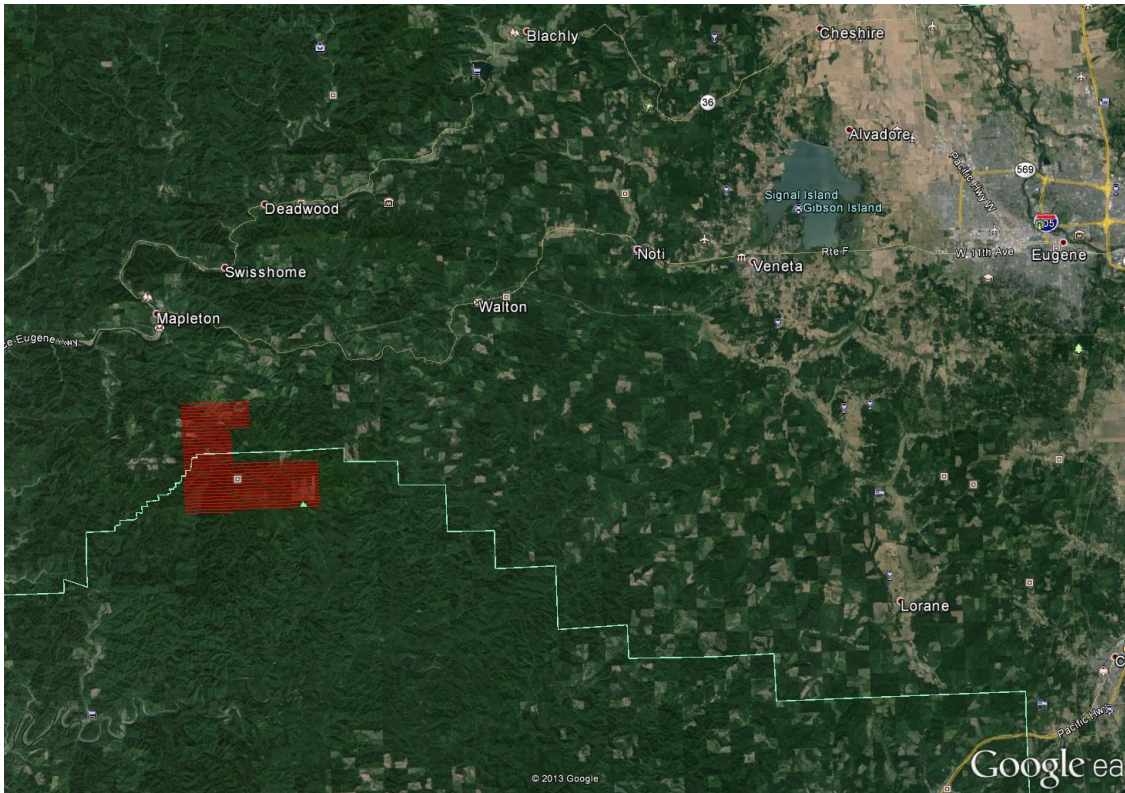

Figure 1 – Shape and location of survey polygon (red) with the planned flight lines shown in red. (Google Earth).

3. Data Collection

a) **Survey Dates**: The survey took place on August 03 and August 04, 2013 (DOY 215 and 216).

b) **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	3.9 hrs
Flight Speed	+/- 60 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.0 hrs.
Swath Width	436.7 m	Scan Frequency	45 Hz	Total Swath Area	47.15 km^2
Swath Overlap	Min 50 %	Scan Angle	± 22°	Total AOI Area	42 km^2
Point Density	6.87 p/m²	Scan Cutoff	2.0°	Pass spacing	218 m

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

c) **Ground GPS:** Three GPS reference station locations were used during the survey: two of them belong to the national CORS network and the remaining one was established by NCALM at the operational airport in Eugene. All GPS reference observations were logged at 1 Hz. Table 3 (below) gives the coordinates of the stations and Figure 2 shows the project area and the GPS reference station locations.

GPS station	1023	LFLO	LPSB
Agency	NCALM	NOAA/NGS	NOAA/NGS
Latitude	44.11439	43.98360	44.05123
W Longitude	123.21199	124.10769	123.09007
GRS80 Height	90.486	-6.044	118.103

Table 3 – Coordinates of GPS reference stations in NAD83 (2011) Epoch 2010.0000 - Ellipsoid Height in meters.
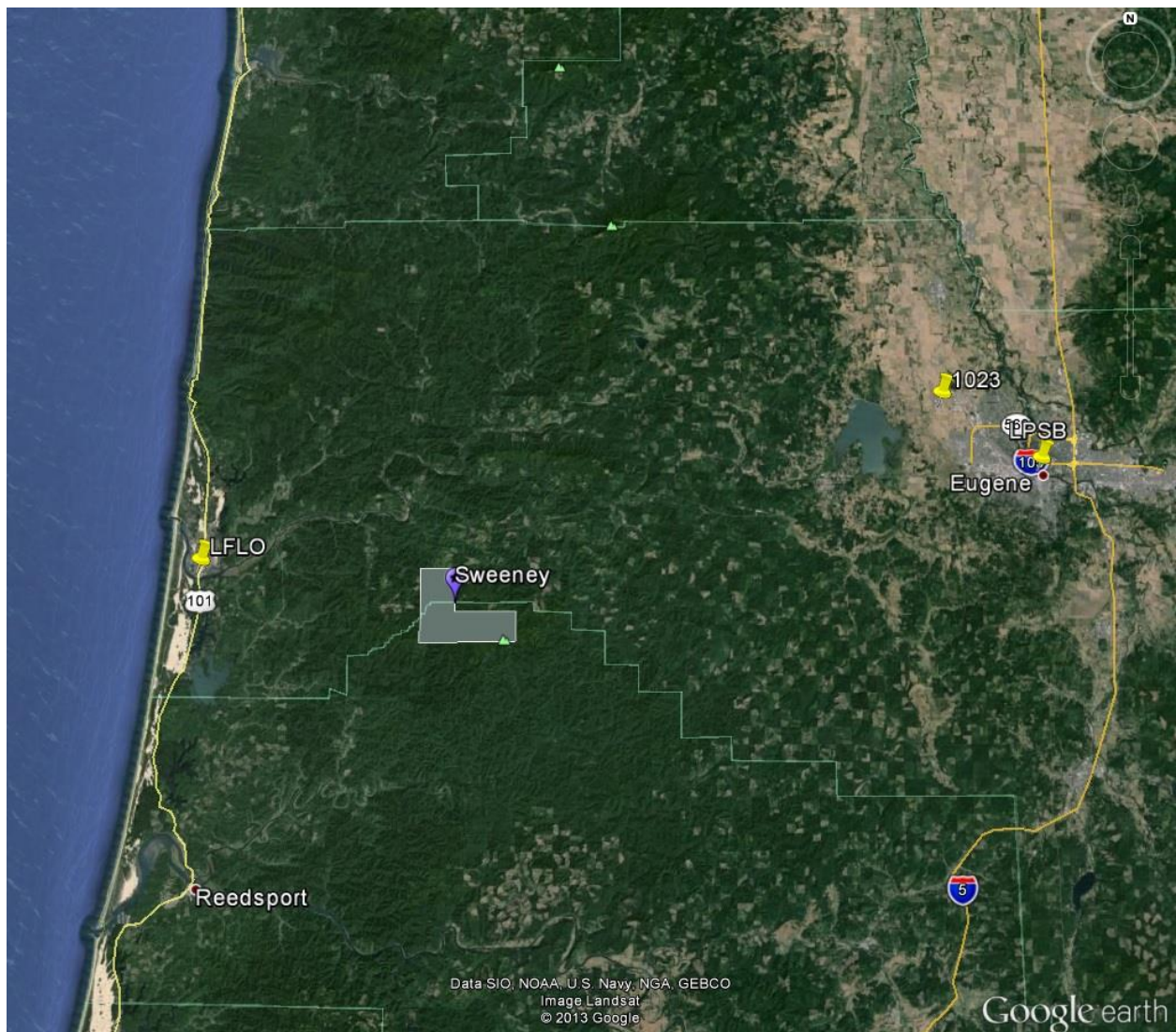

Figure 2 - Project area and GPS reference locations.

4. GPS/IMU Data Processing

Reference coordinates (NAD83 (2011) Epoch 2010.0000) 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 at least three of the five available 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

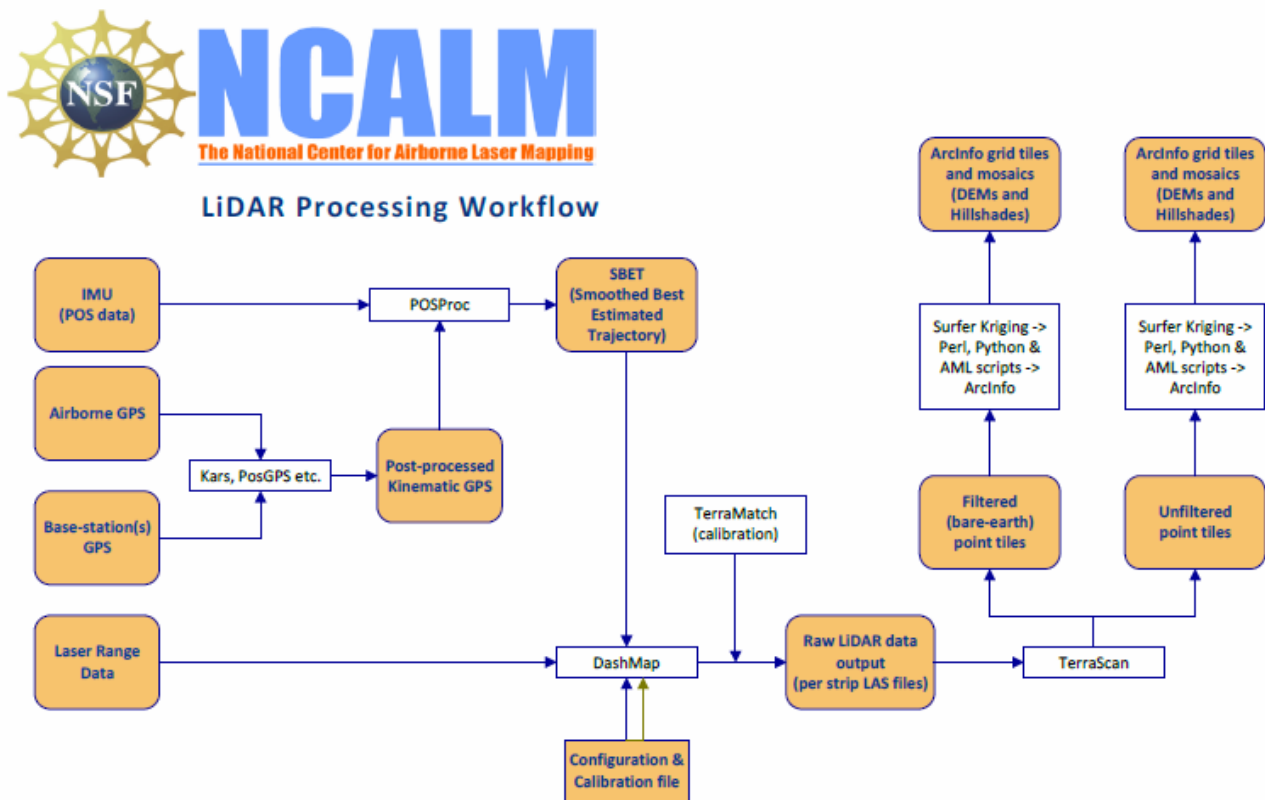The following diagram (Figure 3) shows a general overview of the NCALM LiDAR data processing workflow

Figure 3 - NCALM LiDAR Processing Workflow

Classification done by automated means using TerraSolid Software (TerraScan Version 13.015). http://www.terrasolid.fi/en/products/4

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

a) Relative accuracy

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. After calibration values are determined project flight lines are checked for average mismatch. For this project the average delta Z for project flight lines is approximately 0.083 meters with a standard deviation of 0.041 meters.

b) Absolute accuracy

No ground check points were collected for this project so 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

a) **Horizontal Datum**: NAD83 (2011)
b) **Vertical Datum:** NAVD88 (GEOID 12a)
c) **Projection:** UTM Zone 10N – meters.
d) **File Formats:**

1. Point Cloud in LAS format (Version 1.2), 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_YYYYYY. For example if the tile bounds coordinate values from easting equals 431000 through 432000, and northing equals 4862000 through 4863000 then the tile filename incorporates 431000_4862000. 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' and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'ume431000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'ume431000sh'.