Data Collection and processing report for the Seed project:

"Integration of Airborne LiDAR, Ground-based LiDAR and Synthetic Aperture (SAR) Data to Estimate Tree Height and Above Ground Biomass in the South Florida Everglades Wetland Ecosystem."

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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 06SEN/CON195 mounted in a twin-engine Piper Chieftain aircraft (Tail Number N400JM). 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 1^{st}, 2^{nd}, 3^{rd}, 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 3 rectangular polygons located in Everglades National Park west of Homestead, Florida. The polygon dimensions from west to east are: mangrove 1.5 x 16 km with an enclosed area of 24 km^2; cypress 2 x 4 km with an enclosed area of 8 km^2; and pine 2 x 4 km with an enclosed area of 8 km^2 for a total area in all three polygons equal to 40 km^2. The location and extent of the polygons is shown below in Figure 1.

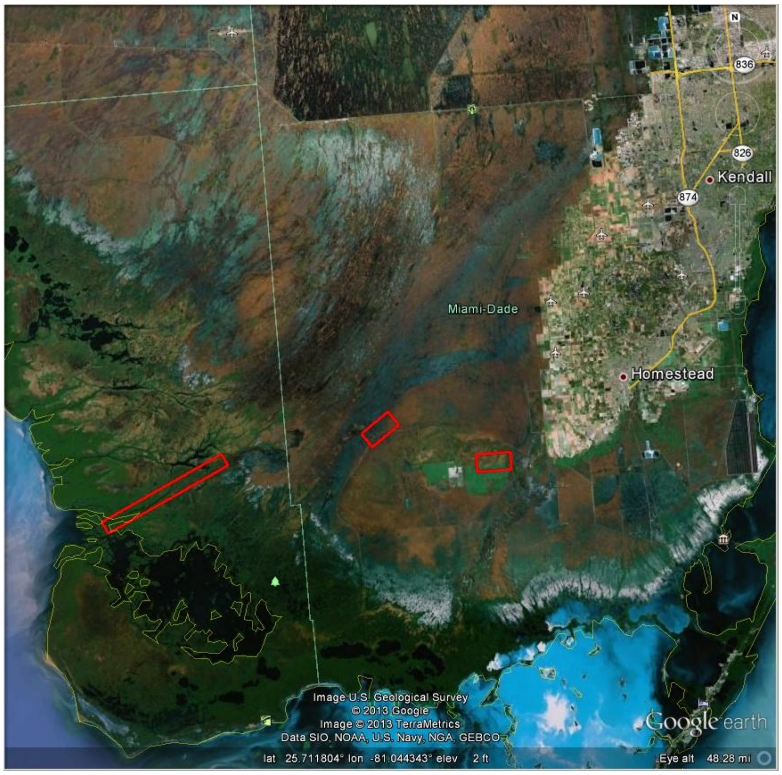

Figure 1 – Shape and location of survey polygons (Google Earth).

3. Data Collection

a) **Survey Dates**: The survey took place on November 17, 2012 (DOY 322) following plan file: Feliciano_Seed_FL_125kHz_V2.pln. The plan consisted of 33 project lines running northeast to southwest as depicted below in Figure 2. Figure 2 also shows the planned survey parameters from the flight planning software.

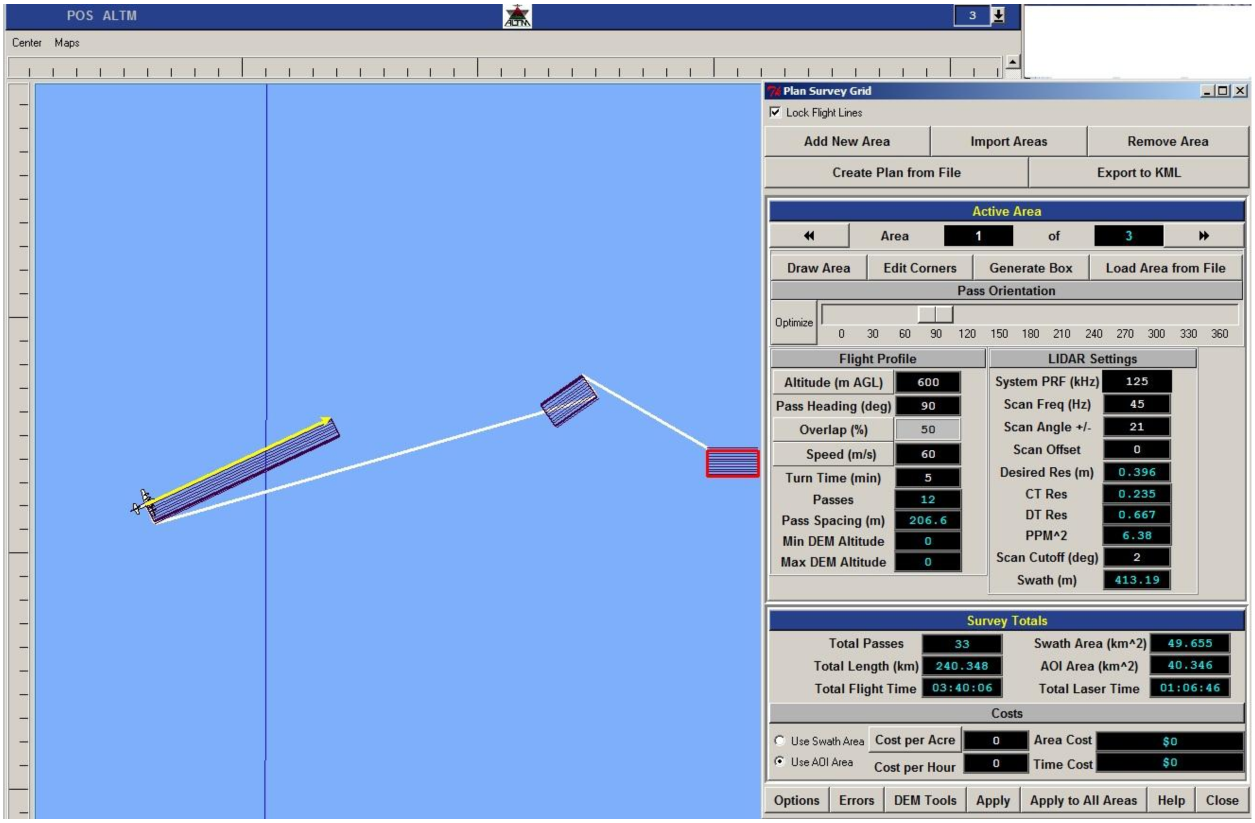

Figure 2 – Shape and location of survey polygon (Google Earth).

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	3.67 hrs
Flight Speed	60 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.1 hrs
Swath Width	360 m	Scan Frequency	45 Hz	Total Swath Area	50 km^2
Swath Overlap	50%	Scan Angle	± 21°	Total AOI Area	40 km^2
Point Density	6.4 p/m²	Scan Cutoff	2°		

Table2 – Survey Parameters and Totals.

c) Ground GPS: Four GPS reference station locations were used during the survey, three of these stations are part of the FLDT GPS network (see http://www.myfloridagps.com/frmIndex.aspx for more information) and the fourth station was operated by NCALM at the Hollywood airport. All ground GPS observations were 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	ZMA1	RMND	MTNT	KHWO
Operating agency	FLDT	FLDT	FLDT	NCALM
Latitude	25 49 28.58534	25 36 49.58911	25 51 56.76077	26 00 14.69163
Longitude	80 19 09.06615	80 23 02.14038	80 54 25.18638	80 14 32.78920
Ellipsoid Height (m)	-6.408	-14.086	-18.928	-24.086

Table 3 – GPS Coordinates of ground reference stations

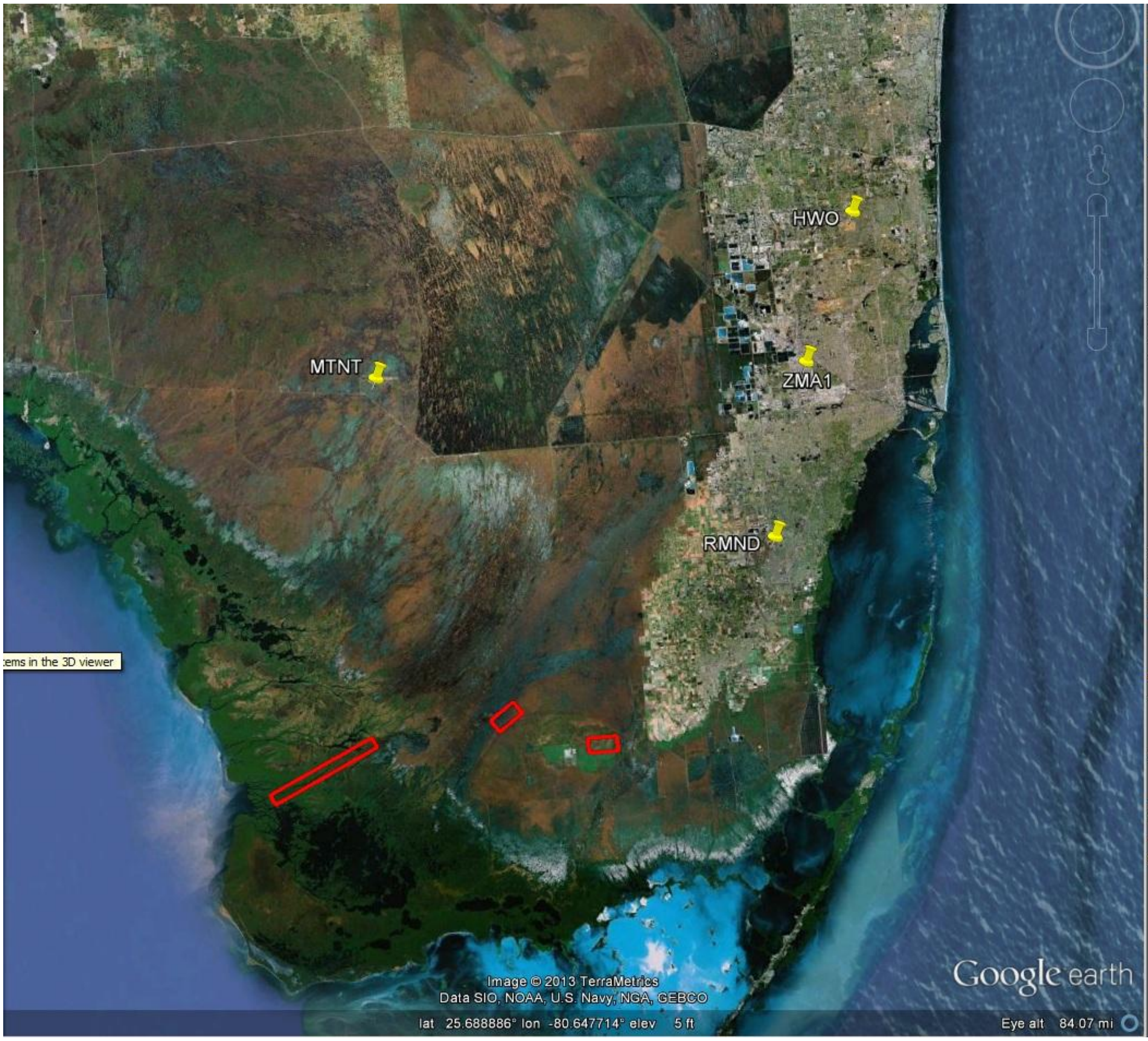

Figure 3 – Location of the GPS Stations used in the survey (Google Earth).

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

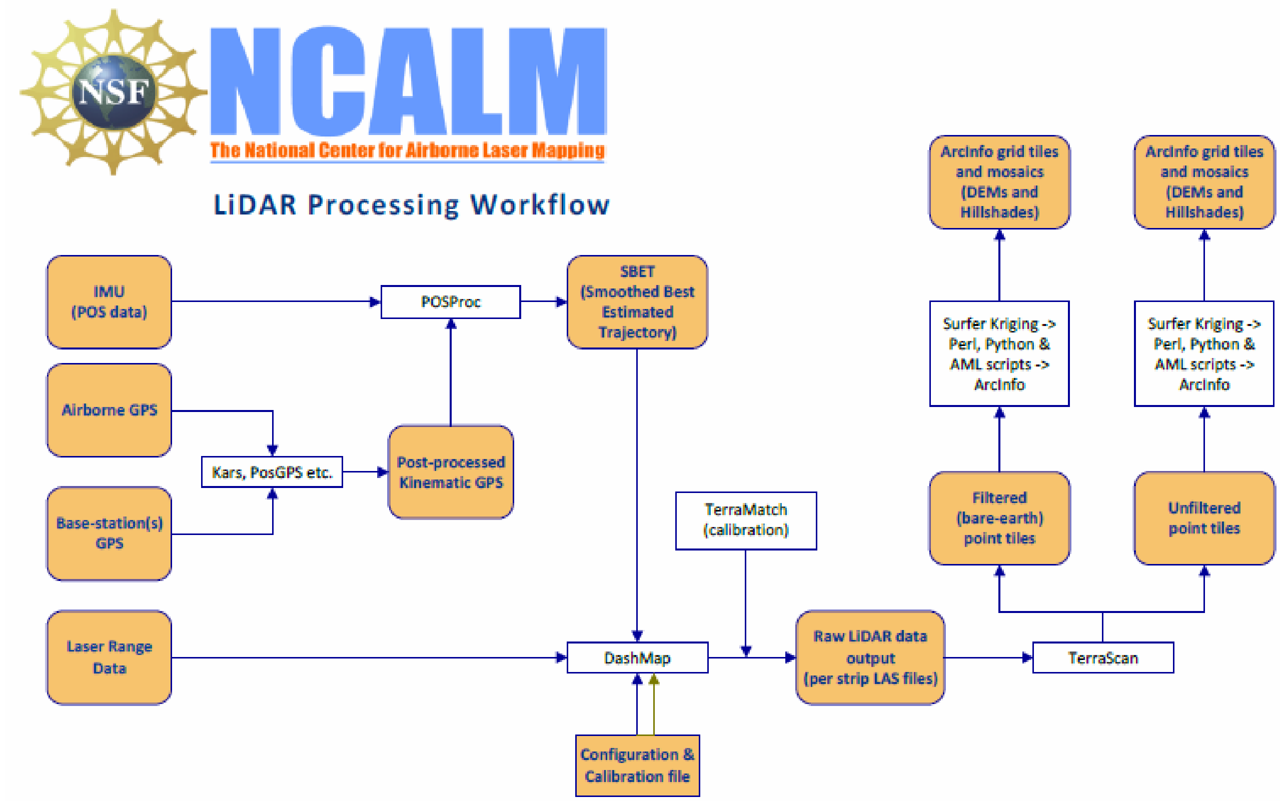

Figure 4 NCALM LiDAR Processing Workflow

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) Epoch: 2010
b) **Vertical Datum:** GEOID 12A
c) **Projection:** UTM Zone 17N
d) **Units:** Meters
e) **File Formats:**

1. Classified Point Cloud in LAS 1.2 format in 1 km square tiles.
2. ESRI format 1-m DEM from default-class points.
3. ESRI format 1-m Hillshade raster from default-class points

f) **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 499000 through 500000, and northing equals 2809000 through 2810000 then the tile filename incorporates 499000_2809000. 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' (indicating that the DEM is made using default-class points) and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'ume617000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'ume617000sh'.

7. Notes

Some additional data were supplied to the PI in the form of RGB imagery and full waveform files. These data were supplied as a courtesy and were not part of the original seed proposal.