Quantifying the evolution and stability of coarse alluvial channels, Henry Mountains, Utah:
SEED Project

PI: Lindsay Olinde

University of Texas at Austin Dept Geological Sciences, 1 University Station C9000, Austin, TX 78712	e-mail: lolinde@mail.utexas.edu Phone: (225) 773-1229

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 Chieftain aircraft (Tail Number N931SA). 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	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/Gemini_SpecSheet_100908_Web.pdf).

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

2. Area of Interest.

The survey area consisted of an irregular polygon located 15 km west of the small paved airstrip at Hite, Utah. The polygon is approximately 80 square km and measured 10 km wide by 8 km long and is shown below (with approximate flight lines) in Figure 1.

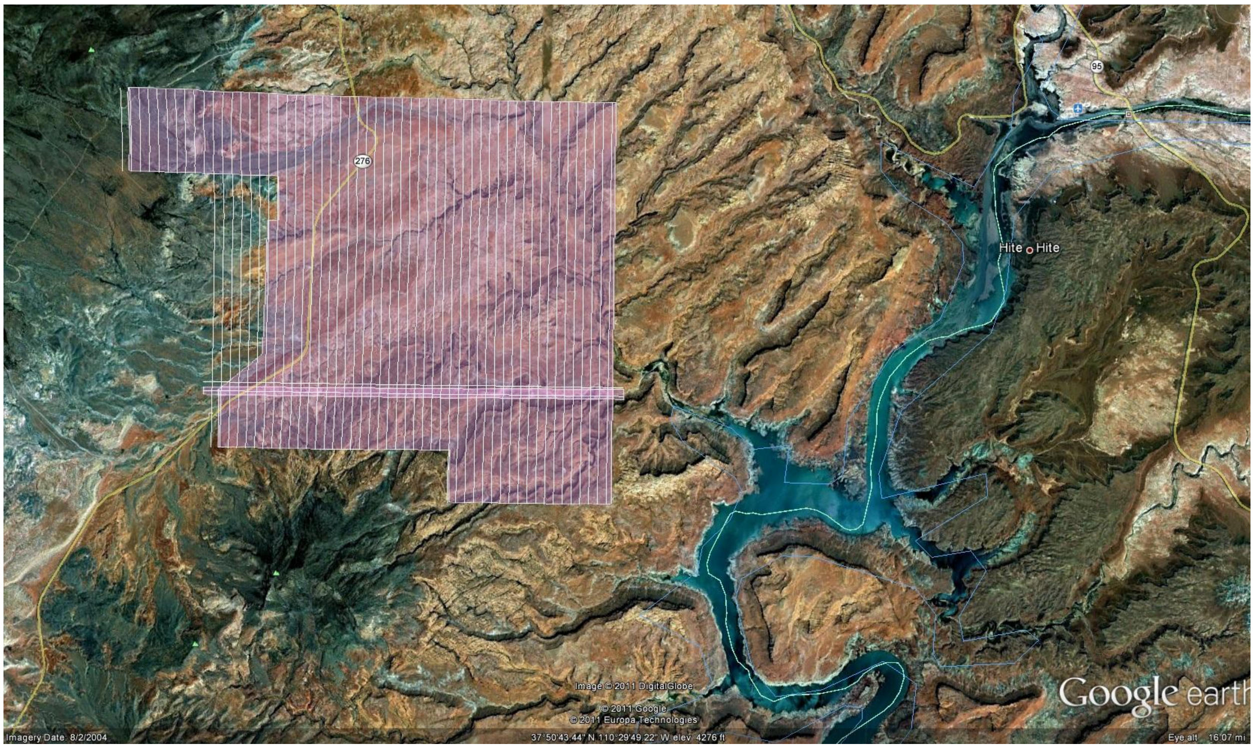

Figure 1 – Shape and location of survey polygon (Google Earth).

3. Data Collection

a) Survey Dates: The survey took place on September 7, 2011 (DOY 250). Figure 2 shows the available coverage.

b) Airborne Survey Parameters: The 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	6.5 hrs
Flight Speed	65 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.8 hrs
Swath Width	390 m	Scan Frequency	45 Hz	Total Swath Area	81.5 km^2
Swath Overlap	50%	Scan Angle	± 21°	Total AOI Area	73 km^2
Point Density	6.7 p/m^2	Scan Cutoff	3°		

Table2 – Survey Parameters and Totals.

c) Ground GPS: Three GPS reference station locations were used during the survey: BDG0, HITE, and ROW_. All 3 stations were set by NCALM. All GPS observations were logged at 1 Hz. Table 3 gives the coordinates of the stations.

GPS station	BDG0	HITE	ROW_
Operating agency	NCALM	NCALM	NCALM
Latitude	37.58201116	37.89384724	37.8941517
Longitude	-109.4828238	-110.3768608	-110.3764326
Ellipsoid Height (m)	1760.788	1174.932	1179.208

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 3) shows a general overview of the NCALM LiDAR data processing workflow

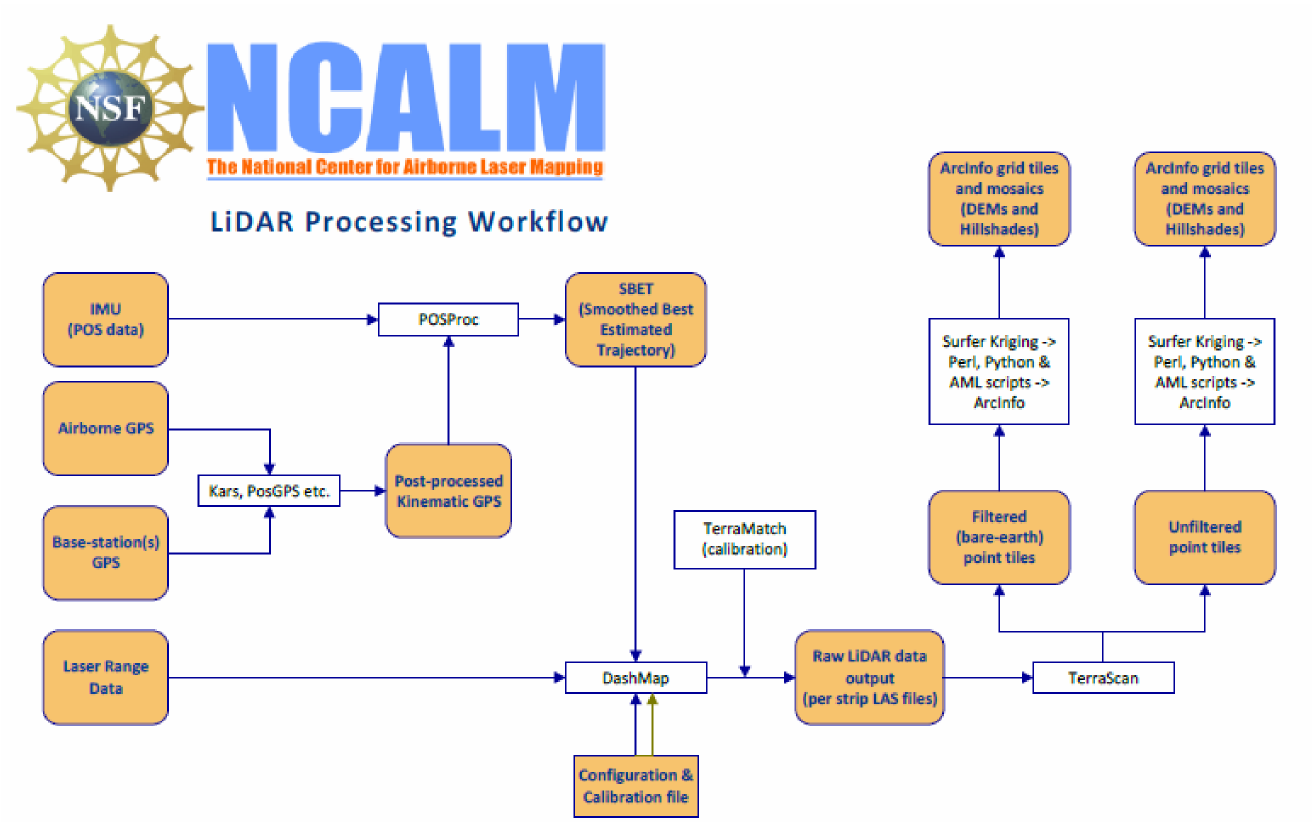

Figure 2 NCALM LiDAR Processing Workflow

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 .

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
http://www.terrasolid.fi/en/products/4

6. Data Deliverables

a) **Horizontal Datum**: NAD83(2011)
b) **Vertical Datum:** GEOID 09
c) **Projection:** UTM Zone 12N
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 534000 through 535000, and northing equals 4184000 through 4185000 then the tile filename incorporates 534000_4184000. 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 'fme' or 'ume' (depending whether the DEM is made using ground points or all points) and the lowest Easting coordinate rounded to the nearest 1000, for e.g. 'fme534000'. The hillshade files have a prefix 'sh' after the name, for e.g. 'fme534000sh'.

7. Notes

1. This area is difficult to classify by automated methods because of the large number of cliff edges. A classified data product was not requested for the 2008 data delivered to Skye Corbett because of this request and the fact that the desert vegetation is so sparse.

2. For this 2011 project both a default (unclassified) DEM and a ground-class DEM will be delivered. In project areas devoid of vegetation the default DEM will yield a better representation of the natural ground than the ground-class DEM, but the ground class DEM may be of more value in areas of thick brush where the ground is obscured. Be aware that the ground-class DEM may not be as accurate of a representation of the cliff edges as the default DEM. Note that the ground classification algorithms have been set in a way to allow many more errors in the direction of including vegetation hits in the ground class than the other way round (ground hits classed as vegetation). There is always a trade-off of these error types depending on the filter parameters.