Data Collection and processing report for Blue and Colorado Rivers Collection

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1. Sensors Description and Specifications

Four sensors were used to collect data over the target areas. These are described below.

1.1 Gemini LiDAR

Optech Gemini Airborne Laser Terrain Mapper (ALTM) serial number 06SEN/CON195 is an infrared laser mapping sensor. 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 and Glonass) 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/gemini.htm).

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

1.2 Aquarius Lidar

Optech Aquarius Airborne Laser Terrain Mapper (ALTM) is a hybrid laser mapping system as it collects simultaneous land and shallow water-depth measurements. It operates in the green spectrum, thus enabling it to penetrate water. The instrument nominal specifications are listed in Table 2.

Operating Altitude	300-600m AGL, nominal
Range Capture	Upto 4 range measurements, including 1st, 2nd ,3rd and last
Intensity Capture	12-bit dynamic measurement range
Scan FOV	0-25 degrees
Scan Frequency	0-70 Hz
Pulse Rate Frequency	33,50,70 kHz
Laser Footprint on water surface	30 – 60 cm
Position Orientation System	Applanix POS/AV 510 OEM includes embedded BD960 72-channel 10Hz (GPS and Glonass) receiver
Laser Wavelength/Class	532 nm
Operating temperature	0-35 degree celcius
Full waveform capture	12 bit IWD-2 Intelligent Waveform Digitizer

Table 2 – Optech Aquarius specifications (http://www.optech.ca/pdf/aquarius-specsheet-121010-2PG-WEB.pdf).

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

1.3 DIMAC Digital Camera

Dimac digital camera is a full frame CCD imaging sensor with a resolution of 60 MP, mounted on a vibration isolation mount. The instrument nominal specifications are listed in Table 3

Sensor size	53.9 mm x 40.4 mm
Pixel size	6 µm X 6 µm
Lens Focal Length	70 mm
Shutter	Electro-Mechanical iris mechanism 1/125 to 1/500 sec., f-stops: 4,5.6, 8,11,16
Image Output	8984 x 6732 pixels (60 MP); 8 or 16 bits per channel; 24 bit RGB: 180 MB; 48 bit RGB: 360 MB
True FMC	Electro-mechanical driven by Piezo technology

Table 3 – DIMAC Digital Camera specifications

1.4 CASI-1500 Hyperspectral sensor

CASI-1500 is a pushbroom type hyperspectral imaging sensor sold by ITRES. It is mounted on a vibration isolated mount together with the LIDAR sensor. The instrument nominal specifications are listed in table 4

Sensor type	VNIR Pushbroom sensor (Compact Airborne Spectrographic Imager)
Spectral Range	380-1050 nm
No. of Spectral Channels	288
No. of Across Track pixels	1500
Total Field of View	40 degrees
Instant Field of View	0.49 mRad
Spectral Width Sampling/Row	2.4 nm
Spectral Resolution	< 3.5 nm
Pixel Size	20 µm X 20 µm
Dynamic Range	14 bits

Table 4 – CASI-1500 Hyperspectral sensor specifications (For more info see manufacturer's website: http://www.itres.com/products/imagers/casi1500/)

2. Areas of Interest.

The survey area was located over the confluence of Blue and Colorado rivers in Colorado, south of Kremmling, Colorado. The location of the area is shown in Figures 1.

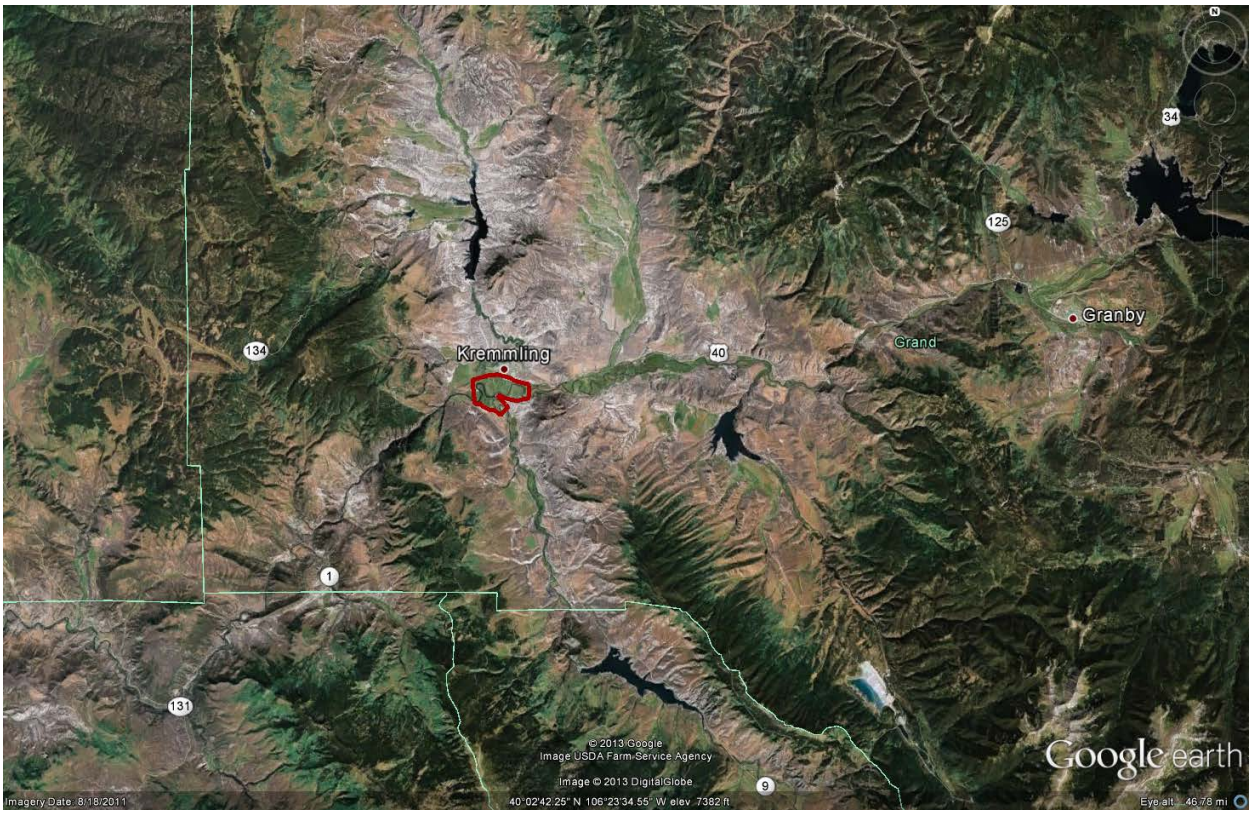

Figure 1 – Shape and location of survey polygon for Blue/Colorado River (Google Earth).

3. Data Collection

a) Survey Dates:
The data collection for Colorado/Blue River took place on September 5, 2012 and September 6, 2012 (DOY 249 and 250). Table 5 lists the dates and the Survey Totals.

Date	DOY	Sensors Flown	Time of flight (hrs)	Laser On time
9/5/12	249	Aquarius, DIMAC	2.54	0.87
9/6/12	250	Gemini, CASI	1.9	0.68

b) 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 6 gives the coordinates of the stations.

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 6 – 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 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

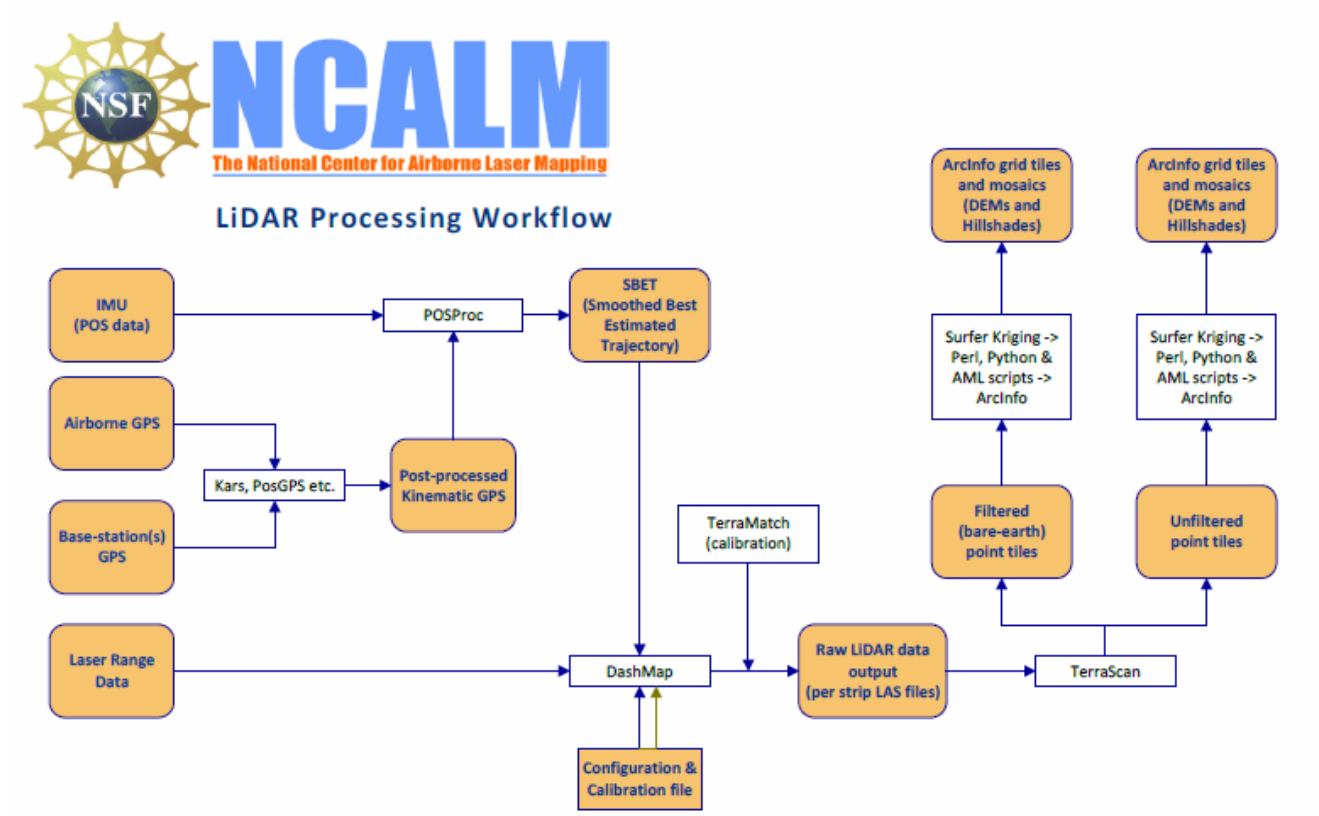

Figure 2 NCALM LiDAR Processing Workflow

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 – 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 13N
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.