Data Collection & Processing Report for 2015 Austin, TX, Rapid Response

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1. LiDAR System Description & Specifications

This survey was performed with an Optech ALTM Gemini (serial number: 06SEN195) mounted in a twin-engine Piper PA-31-350 Navajo Chieftain (tail number: N154WW). The instrument nominal specifications are listed in **Table 1**.

Operating Altitude	150–4000 m, nominal
Horizontal Accuracy	1/5,500 × altitude (m AGL), 1σ
Elevation Accuracy	5– 35 cm, 1σ
Range Capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity Capture	12-bit dynamic range for all recorded returns, including last return
Scan FOV	0–50°, programmable in increments of ± 1°
Scan Frequency	0–70 Hz
Scanner Product	Up to Scan Angle × Scan Frequency = 1000
Roll Compensation	± 5° 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 10 Hz (GPS) receiver
Laser Wavelength/Class	1064 nm/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

2. Area of Interest

The requested survey area consisted of a polygon located over downtown Austin, TX, and the surrounding area. The polygon encloses approximately 157 km² (60.5 mi²). **Figure 1** is an image from Google Earth showing the location of the survey.
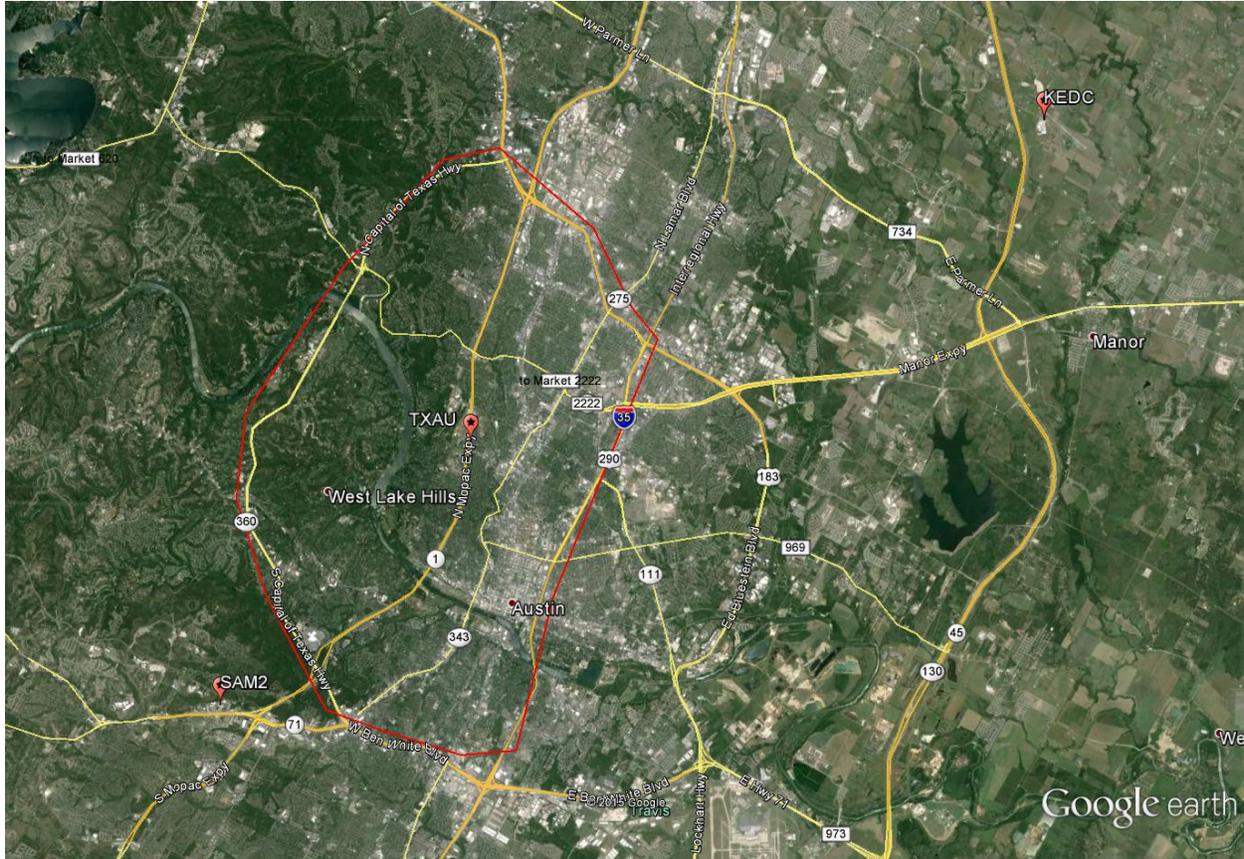

Figure 1: Location of survey polygon (in red) and GPS reference stations

3. Data Collection

a) Survey Dates: The survey took place on June 12–13, 2015 (DOY 163 & 164).

b) Airborne Survey Parameters: Survey parameters are provided in **Table 2**.

Nominal Flight Parameters		Equipment Settings		Survey Totals	
Flight Altitude	600 m	Laser PRF	125 kHz	Total Flight Time	11.07 hr
Flight Speed	+/- 65 m/s	Beam Divergence	0.25 mrad	Total Laser Time	5.93 hr
Swath Width	280 m	Scan Frequency	60 Hz	Total Swath Area	190 km^2
Swath Overlap	~50%	Scan Angle	± 14°	Total AOI Area	157 km^2
Point Density	13 pt/m²	Scan Cutoff	1°	Pass spacing	150 m

Table 2: Nominal flight parameters, equipment settings, and survey totals (actual parameters vary with terrain)

c) Ground GPS: Three GPS reference stations were used during the survey: two belonged to the national CORS network, and the remaining one was established by NCALM at the Austin Executive Airport. All GPS reference observations were logged at 1 Hz. **Table 3** gives the coordinates of the stations, and **Figure 1** and **Figure 2** (above) show the project area and GPS reference station locations.

GPS Station	TXAU	SAM2	KEDC
Agency	NGS	NGS	NCALM
Latitude	30°18'42.08819"	30°14'20.44839"	30°24'02.66870"
West Longitude	97°45'22.71225"	97°50'11.32390"	97°34'21.23832"
Ellipsoidal Elevation	193.873 m	212.800 m	164.100 m

Table 3: Coordinates of GPS reference stations in NAD83(2011) epoch 2010.00, ellipsoid height in meters

4. GPS/IMU Data Processing

Reference coordinates (NAD83(2011) epoch 2010.00) for all stations are derived from observation sessions taken over the project duration and submitted to the NGS's 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 (except in rare instances) are blended solutions from at least two of the three 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 7.0). 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

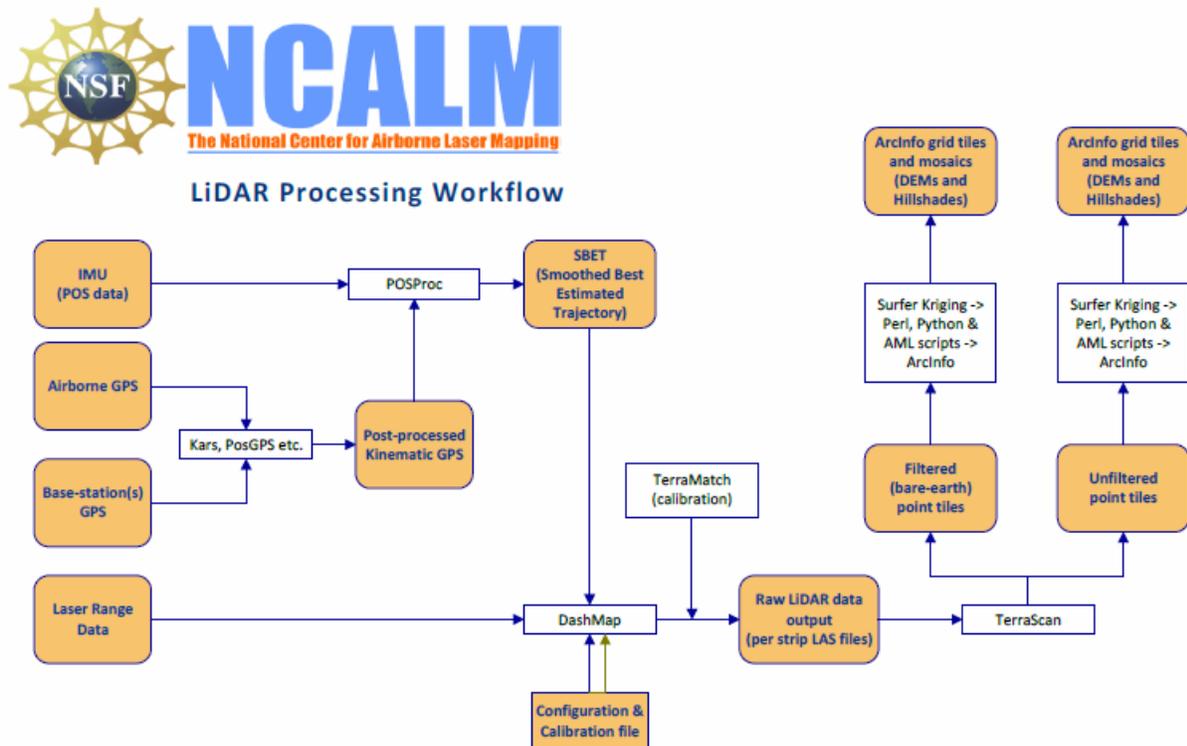The following diagram (**Figure 2**) shows a general overview of the NCALM LiDAR data processing workflow.

Figure 2: NCALM LiDAR processing workflow

Classification was done by automated means, using TerraSolid Software (TerraScan Version 15.006: http://www.terrasolid.com/products/terrascanpage.php).

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 datasets. 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 sensor's three boresight angles (roll, pitch, and yaw) and scanner mirror scale factor was done by automated means using TerraSolid Software (TerraMatch Version 15.005). Project lines or off-project lines flown with opposite headings, combined with perpendicular cross lines, are used as input in TerraMatch. These calibration values are checked on a flight-by-flight basis.

After the calibration values are optimized, project flight lines are output and classified into ground and non-ground classes. Surfaces are developed for each flight strip from the ground class points, then these individual flight strip surfaces are differenced, and a value for the magnitude of the height mismatch over the entire project area is calculated.

For the surveyed area, the average magnitude for vertical mismatch of ground surfaces (unsigned vertical differences between flight strips) in overlap zones is 0.073 m.

b) Absolute Accuracy: No ground check points were collected for this project, so a small (< 0.15 m) vertical bias in the elevations of the final pointcloud 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 14N

d) Units: Meters

e) File Formats:

1. Pointcloud in LAS format (Version 1.2), classified as ground or non-ground, in 2 km^2 rectangles.
2. ESRI format 0.5-m DEM from ground classified points.
3. ESRI format 0.5-m Hillshade raster from ground classified points
4. ESRI format 0.5-m DEM from all points (canopy included).
5. ESRI format 0.5-m Hillshade raster from all points (canopy included).

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_YYYYYY*. For example, if the tile bounds are the coordinate values from Easting 550000 through 551000, and Northing 4330000 through 4331000, then the tile filename incorporates *550000_4330000*. The ESRI DEMs are mosaic files created by combining the 1-km tiles.