# Rapid Response Mississippi Flood LiDAR Survey

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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 06SEN185 mounted in a twin-engine Cessna 337 Skymaster aircraft (Tail Number N337P). The instrument nominal specifications are listed in table 1.

| | |
|---|---|
| Operating Altitude | 80- 3500 m, Nominal |
| Horizontal Accuracy | 1/5,500 x altitude (m AGL); 1 sigma |
| Elevation Accuracy | 5 - 30 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 12-channel 10Hz GPS 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/Brochures/ALTM3100EAwspecsfnl.pdf).**

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

## 2. Areas of Interest.

The survey area consisted of a polygon located near the confluence of Ohio and Mississippi rivers, about 35 km east of Sikeston in the southeastern edge of the state of Missouri. The survey location is shown below in Figure 1.


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

# 3. Data Collection

**a) Survey Date**: The survey took place over a period of three days i.e. June 21, 2011 (DOY 171) through June23, 2011(DOY 173). It consisted of four flights. Details are given below in Table 2

| Flight | Date | DOY | Flight Time | Laser on Time |
|---|---|---|---|---|
| 1 | 6/21/2011 | 171 | 4.58 | 2.08 |
| 2 | 5/11/2011 | 172 | 2.89 | 1.25 |
| 3 | 5/12/2011 | 173 | 3.83 | 1.89 |
| 4 | 5/13/2011 | 173 | 2.01 | 0.82 |
| | | Total | 13.32 | 6.04 |

**Table 2 – Flight information**

**b) Airborne Survey Parameters:** The survey parameters are provided in Table 3 below

| Nominal Flight Parameters | | Equipment Settings | | Survey Totals | |
|---|---|---|---|---|---|
| Flight Altitude | 600 m | Laser PRF | 100 kHz | Total Passes | 52 |
| Flight Speed | 60 m/s | Beam Divergence | 0.25 mrad | Total Swath Area | 186.7 $km^2$ |
| Swath Width | 277 m | Scan Frequency | 65 Hz | Total AOI Area | 177 $km^2$ |
| Swath Overlap | 50% | Scan Angle | ± 15° | | |
| Point Density | 10.36 p/$m^2$ | Scan Cutoff | 2° | | |

**Table 3 – Survey Parameters and Totals.**

**c) Ground GPS**

Four GPS reference station locations were used during the survey; MOCH, MAIR, SIK2 and KSI3. SIK2 and KSI3 were setup by NCALM. MOCH is part of the NGS CORS network. MAIR is part of the UNAVCO PBO stations network. All reference GPS observations were logged at 1 Hz. Table 4 gives the coordinates of the stations.

| **GPS station** | **MOCH** | **MAIR** | **SIK2** | **KSI3** |
|---|---|---|---|---|
| Operating agency | NGS | UNAVCO | NCALM | NCALM |
| Latitude | 36.918117 | 36.846569 | 36.797652 | 36.885443 |
| Longitude | -89.318774 | -89.356746 | -89.211082 | -89.564994 |
| Ellipsoid Height (m) | 71.413 | 68.587 | 64.568 | 68.569 |

**Table 4 – 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 two 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

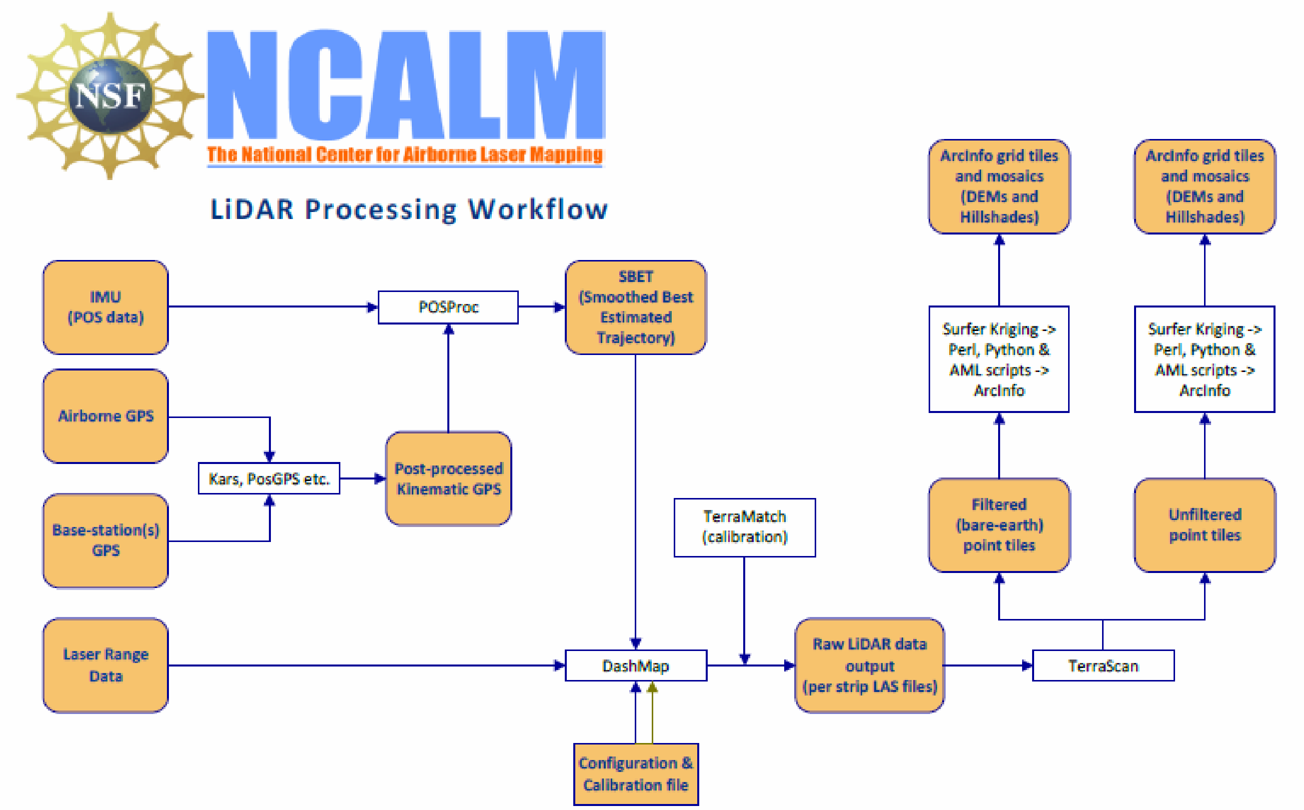


**Figure 2 NCALM LiDAR Processing Workflow**

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 is done by automated means using TerraSolid Software

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

## 6. Data Deliverables

a) **Horizontal Datum**: NAD83(CORS96)

b) **Vertical Datum:** NAVD 88, GEOID 09

c) **Projection:** UTM Zone 16N

d) **File Formats:**

1. ESRI format 1-m DEM from ground classified points.
2. ESRI format 1-m Hillshade raster from ground classified points
3. ESRI format 1-m DEM from all points (canopy included).
4. 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 296000 through 29700, and northing equals 4073000 through 4074000 then the tile filename incorporates 296000_4073000. These tile footprints are available as an AutoCAD DXF or ESRI shape file. The ESRI DEMs are single mosaic files created by combining together the 1KM tiles. Their name consists of prefix ‘fme’ and the lowest Easting coordinate rounded to the nearest 1000, for e.g. ‘fme296000’. The hillshade files have a prefix ‘sh’ after the name, for e.g. ‘fme296000sh’.