# LiDAR Survey of Some Alluvial Fans in Death Valley National Park
# May 29 – June 03, 2003

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## 1. LiDAR System Description and Specifications

This survey was performed with an Optech 2033 Airborne Laser Terrain Mapper (ALTM) serial number 98b110 mounted in a twin-engine Cessna 337 Skymaster aircraft (Tail Number N337P). The instrument nominal specifications are listed in table 1.

| | |
|---|---|
| Operating Altitude | 330 - 2000 meters |
| Range Accuracy | 10 cm single shot |
| Range Resolution | 1 cm |
| Relative Accuracy | 5-10 cm @ 33KHz |
| Options | Intensity data; First and Last Pulse Measurements; Extended Altitude (2000 M) |
| Scan Angle | Variable from 0 to +/- 20 |
| Angle accuracy | 0.05 degrees |
| Angle Resolution | 0.01 degrees |
| Scan Frequency | Variable - product of scan rate and scan frequency must be <590 |
| Pulse Rate Frequency | 33 KHz |
| Roll and Pitch Accuracy | 0.04 degrees |
| Heading Accuracy | 0.05 degrees |
| Laser Wavelength | 1047 nanometers |
| Beam Divergence | 0.30 mrad |

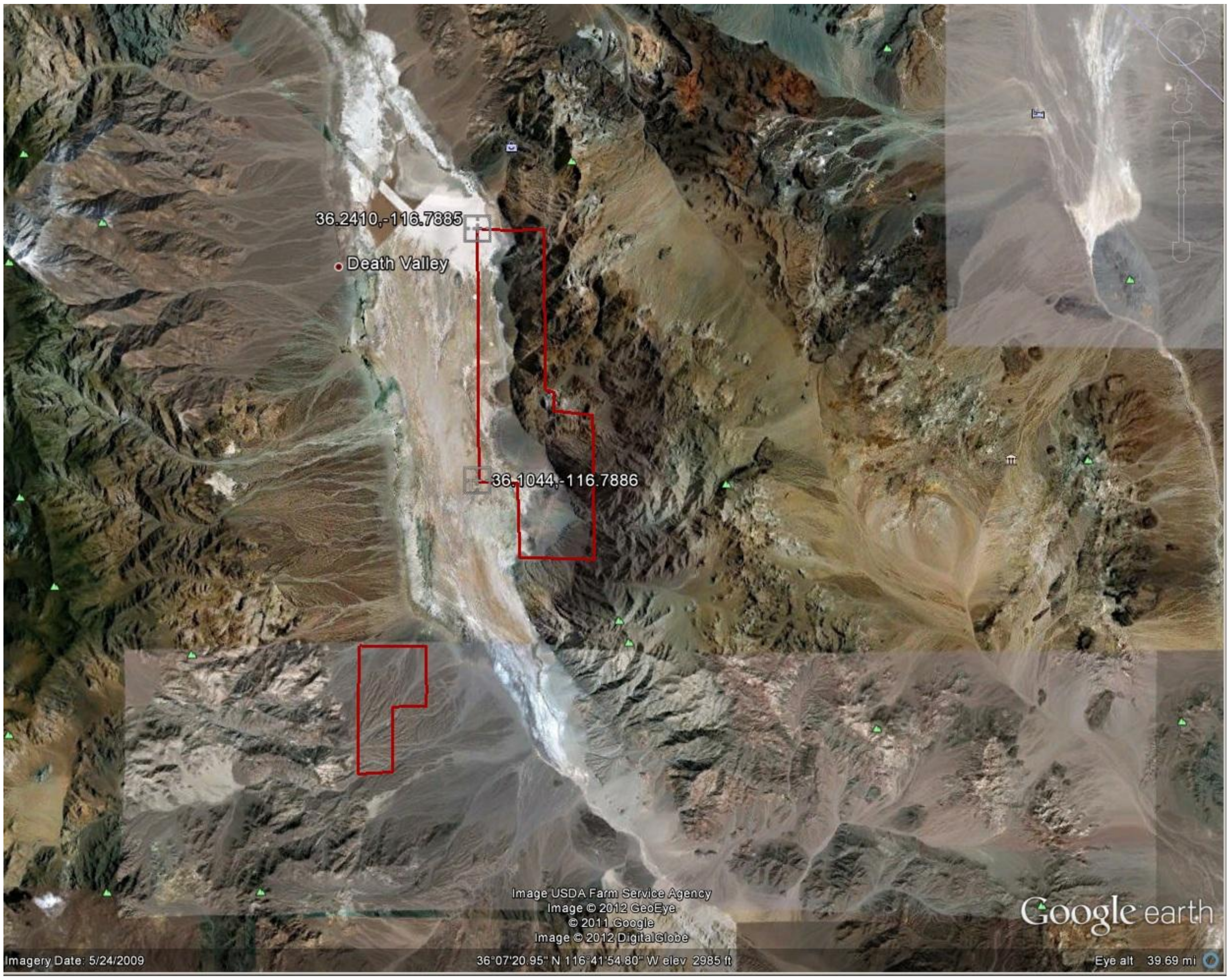
**Table 1 – Optech ALTM 2033 specifications.**

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

## 2. Area of Interest.

The survey area consisted of two polygons totaling 80 square km south of Badwater in Death Valley National Park.

**Figure 1 – Location of survey polygons in Death Valley National Park (Google Earth).**



# 3. Data Collection

**a) Survey Dates:** The survey took place over three flights from 5/29/2003 – 6/03/2003 (DOY 149- 154).

**b) Airborne Survey Parameters:** The planned survey parameters for the survey are provided in Table 2 below:

| Nominal Flight Parameters | | Equipment Settings | | Survey Totals | |
|---|---|---|---|---|---|
| Flight Altitude | 600 m | Laser PRF | 33.3 kHz | Total Flight Time | 9.0 hrs |
| Flight Speed | 60 m/s | Beam Divergence | 0.30 mrad | Total Laser Time | 2.0 hrs |
| Swath Width | 436 m | Scan Frequency | 28 Hz | Total Swath Area | 84 $km^2$ |
| Swath Overlap | 50% | Scan Angle | ± 20° | Total AOI Area | 80.0 $km^2$ |
| Point Density | 1.4 p/m² | Scan Cutoff | 2° | | |

**Table 2 – Death Valley Survey Parameters and Totals.**

**c) Ground GPS:** Two GPS reference station locations were used during the survey: DVPT and HELL. Both of the reference stations collected GPS observations at 1 Hz. Table 3 gives the coordinates of the stations.

| GPS station | DVPT | HELL |
|---|---|---|
| Operating agency | NCALM | NCALM |
| Latitude | 36.46330 | 36.20852 |
| Longitude | -116.87912 | -116.77675 |
| Ellipsoid Height (m) | -97.057 | -108.708 |

**Table 3 – GPS Coordinates of ground reference stations for Death Valley survey**

# 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 all stations.

After GPS processing, the trajectory solution and the raw inertial measurement unit (IMU) data collected during the flights are combined in APPLANIX software POSProc. POSProc implements a Kalman Filter algorithm to produce a final, smoothed, and complete navigation solution including both aircraft position and orientation at 50 Hz. This final navigation solution is known as an SBET (Smoothed Best Estimated Trajectory).

# 5. LiDAR Data Processing Overview

LiDAR point-cloud processing was done in Optech REALM software, ASCII is the only supported output format.

Calibration of roll, pitch, and scanner mirror scale was done manually using cross-lines flown perpendicular to project lines.

Classification of the point cloud into two classes – ground and non-ground_ was performed by automated routines using software developed by researchers at the UF and by Optech software.

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.

# 6. Accuracy Assessment

None performed.

# 7. Data Deliverables

a) **Horizontal Datum**: NAD83(CORS96)
b) **Vertical Datum:** GRS80 (no GEOID model has been applied)
c) **Projection:** UTM Zone 11N
d) **File Formats:**

1. Point cloud data in LAS format, translated from 4-column (XYZi) ASCII tiles.
2. ASCII grid nodes (XYZ) 1-M cell size exported from elevation rasters made from deliverable #1.

# 8. Notes

1. Raw data, flight strips, no longer available – hard drive failure.
2. LAS format only contains XYZi and IS NOT CLASSIFIED.