Evolution of the Hector Mine Earthquake Surface Rupture: a Decadal View (SEED Project)

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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 06SEN195 mounted in a twin-engine Piper Chieftain (Tail Number N31PR). 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+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/pdf/Gemini_SpecSheet_100908_Web.pdf).

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

2. Areas of Interest.

The survey area consisted of a polygon located 90 km East of Victorville, California in the Marine Corps Air Ground Combat Center. The polygon is approximately 48 km long by 1.5 km wide and encloses approximately 75 km². It is shown with red outline below in Figure 1.

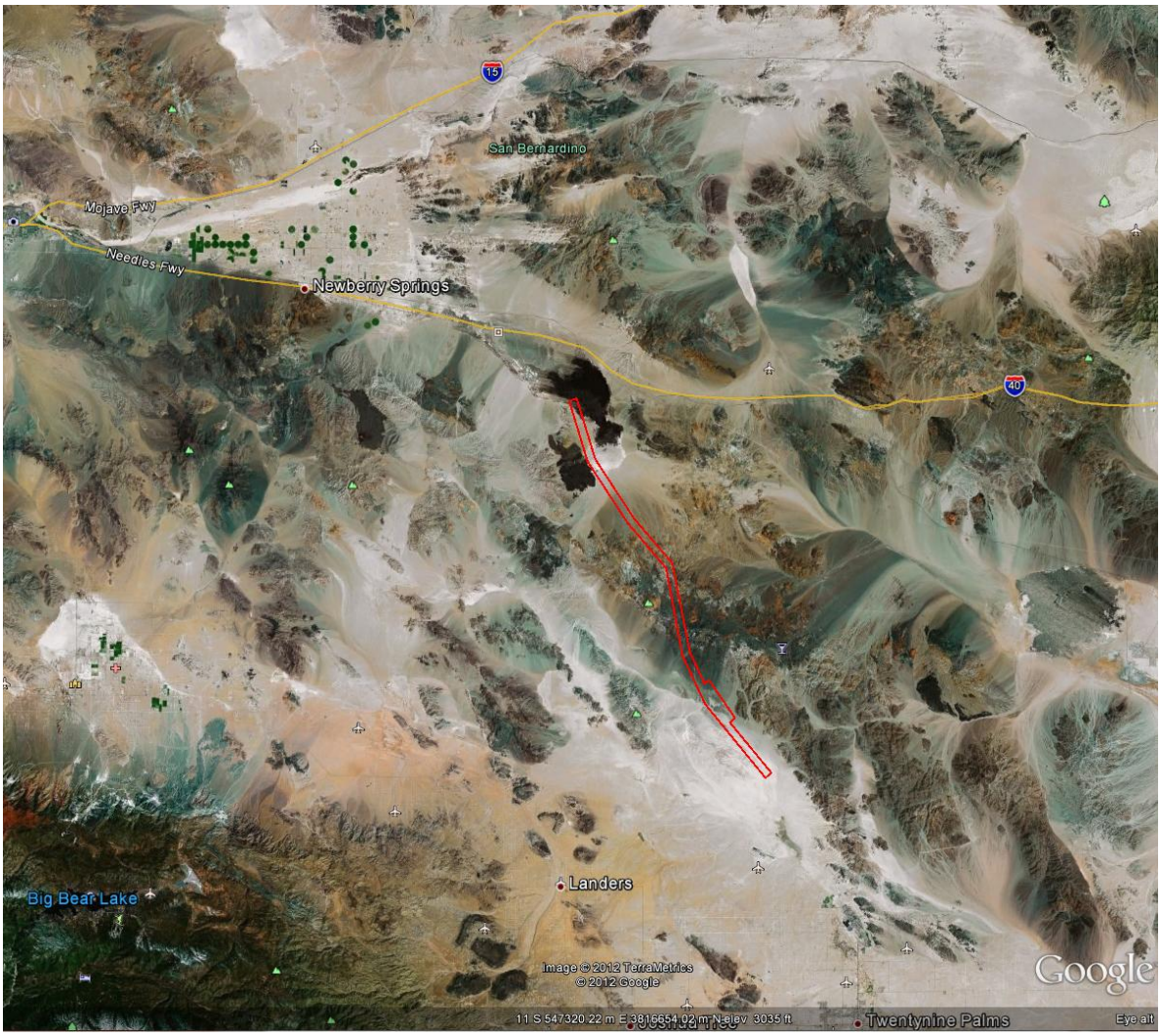

Figure 1 – Shape and location of survey polygon (Google Earth).

3. Data Collection

a) Survey Dates: The survey took place on May 27, 2012 (DOY 148).

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	125 kHz	Total Flight Time	2.5 hrs
Flight Speed	65 m/s	Beam Divergence	0.25 mrad	Total Laser Time	1.3 hrs
Swath Width	344 m	Scan Frequency	45 Hz	Total Swath Area	75 km^2
Swath Overlap	50 %	Scan Angle	± 18°	Total AOI Area	75 km^2
Point Density	10 p/m^2	Scan Cutoff	2.0°		

Table2 – Survey Parameters and Totals.

c) Ground GPS: Six GPS reference station locations were used during the survey: Five are part of UNAVCO's PBO network and one was set-up by NCALM at the 29 Palms Airport (KTNP). All reference GPS observations were logged at 1 Hz. Table 3 gives the coordinates of the stations and Figure 2 shows the project area and the reference GPS station locations.

GPS station	KTNP	HCMN	OPCP	OPCX	OPRD	P604
Agency	NCALM	UNAVCO	UNAVCO	UNAVCO	UNAVCO	UNAVCO
Latitude	34.13562	34.75477	34.36713	34.43008	34.53303	34.93683
Longitude	-115.54579	-116.43008	-116.08377	-116.14948	-116.29228	-116.67145
Height	526.377	568.757	1096.672	1133.833	1400.256	588.443

Table 3 – GPS Coordinates of ground reference stations. Ellipsoid height IGS08 in meters.

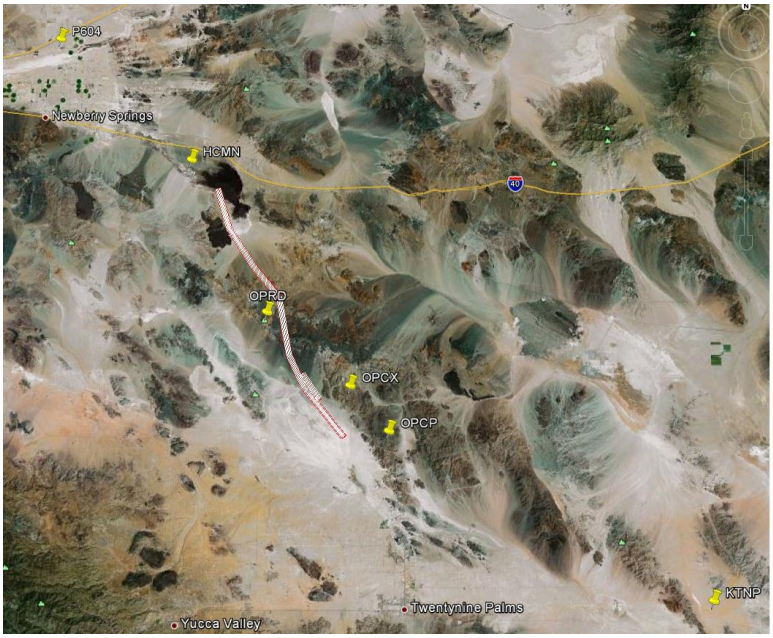

Figure 2 Project area and GPS reference locations.

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

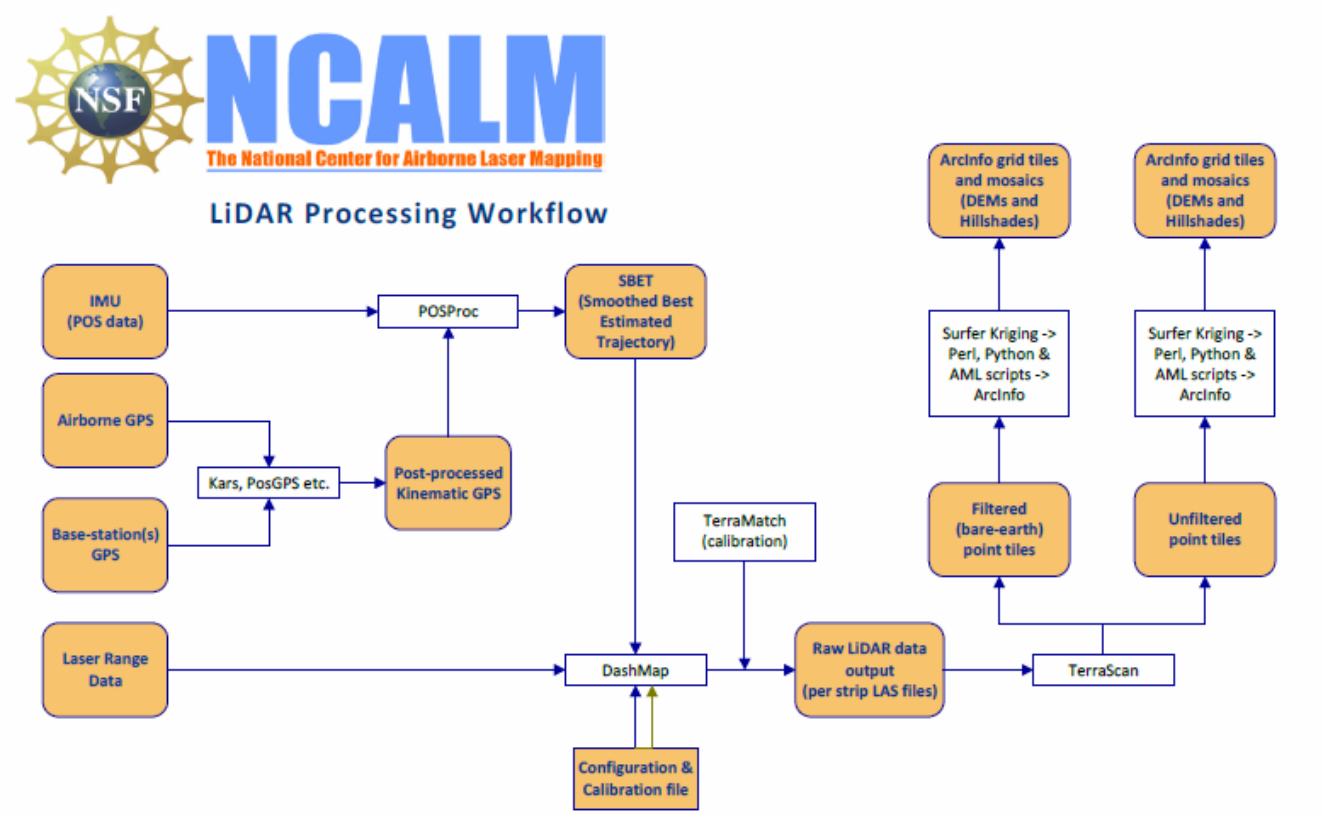

Figure 2 NCALM LiDAR Processing Workflow

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 done by automated means using TerraSolid Software
http://www.terrasolid.fi/en/products/4

6. Data Deliverables

a) **Horizontal Datum**: IGS08
b) **Vertical Datum:** None
c) **Projection:** UTM Zone 11N
d) **File Formats:**

1. Point Cloud in LAS format, all points in default class, 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.

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 555000 through 556000, and northing equals 3843000 through 3844000 then the tile filename incorporates 555000_3843000. 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 ‘umn’ and the lowest Northing coordinate rounded to the nearest 1000, for e.g. ‘umn3801000’. The hillshade files have a prefix ‘sh’ after the name, for e.g. ‘umn3801000sh’.

7. Notes

Point classification was not done on these data per PI request; all points remain in their default point class. Datum is IGS08 per PI request, heights are ellipsoidal.