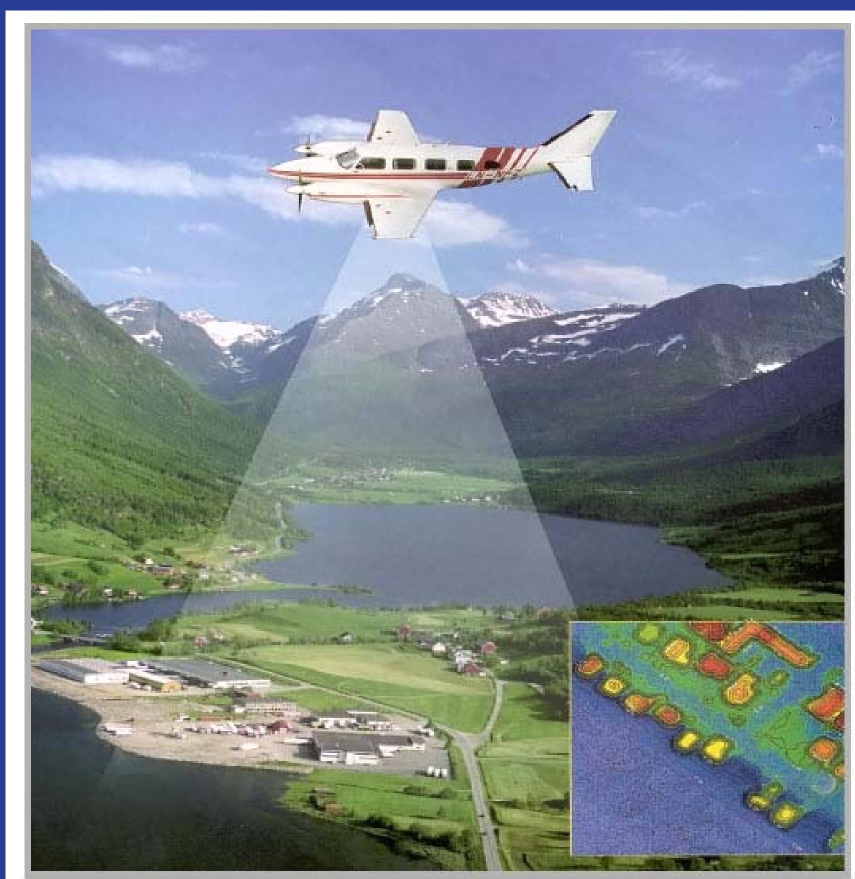
LiDAR ACQUISITION AND PROCESSING REPORT

Project:	Elk Horn River LiDAR Project
Report Area:	Elk Horn River Nebraska
Delivery Order No.:	0005
Contract No.:	W912P9-10D-0538
Date:	10-April-2012
Submitted by:	Wade Williams, Project Manager



US Army Corps of Engineers, St. Louis District

Project Overview

The St. Louis District of the United States Army Corps of Engineers (USACE) contracted with Surdex Corporation in the fall of 2011 to collect high resolution LiDAR elevation data over the Elk Horn River in Nebraska. The project covers approximately 694 square miles over two areas. The southern area is a 177 square miles at the confluence of the Elk Horn & Platte Rivers. The northern area follows the Elk Horn River about 125 miles to the northwest. The average laser ground sample distance required for this project is 1.4 meters.

LIDAR Data Planning and Acquisition:

The following parameters were used in preparing the flight plan.

Flight altitude	8,000’- 9,750’ AMSL
Airspeed	150 knots
Full swath width	1383-1650 meters
Overlap between strips	20 % (average)
Field of View	34.0 degrees
Average Point Spacing	1.25 meters
Scan frequency	37.1 Hz
Pulse Repetition Rate	60,000 - 90,500 Hz
Returns per pulse	4 + intensity

LiDAR data was acquired leaf-off, snow-free and while water bodies are at below to normal levels by Surdex Corporation on November 4-7, 2011. Surdex utilized their twin engine Cessna 335 with a Leica ALS-50-II multi-pulse instrument. Surdex set up GPS base stations for all flights as well as continuously operating reference stations (CORS) were used for the GPS base stations. All flight lines were within 25 miles of a GPS station.

The flight crew is guided by a GPS controlled flight management system, which displays the flight plan; including altitude, heading, cross track deviation and PDOP. During the flight mission, the system operator monitors flight management data, laser information, to ensure a successful mission.

Before and after each LiDAR mission, Surdex Corporation performed a calibration flight to ensure the accuracy of the data to be acquired. This calibration flight consisted of two sets of parallel lines flown in opposite directions, each set perpendicular to each other. These calibration lines were flown over the top of the base airfield and nearby buildings to observe if any horizontal or vertical offset was present. The results of the calibration flights are reviewed in relation to a recent, more rigorous bore sight calibration on the instrument near our office in Chesterfield, MO.

All data in the aircraft, including GPS, IMU (inertial measurement unit, i.e. rotational angles); laser ranges; are recorded onto 72 GB removable hard drives and 1 GB flash memory cards. Upon landing the system operator removes all storage devices from the LIDAR system and the GPS receivers. At the end of each flight day, all data is copied to a second set of data drives for archival purposes. Two copies of all data are maintained throughout our entire process.

Data Processing

Post processing of LiDAR involves the following software packages and procedures:

1. IPAS Pro (Leica)
2. GrafNav (Waypoint)
3. ALS Post-Processor (Leica)
4. TerraScan and TerraModeller (TerraSolid)
5. GeoCue (NIIRS10)

The GPS data is processed, differentially corrected, and its integrity is verified. The IMU data is combined with the GPS and laser range data to create LIDAR elevation points in the project coordinate system. The LIDAR elevation point data are viewed as shaded relief elevation images by flight line. The data is compared with the project boundary and planned flight lines to verify complete data coverage. The flight line data is merged and any areas that that may not be covered with LIDAR are identified and re-flown before the flight crew leaves the project area.

After the data arrives from the field, it is immediately processed and verified. IMU data is processed and checked for gyro bias, systematic errors, and position error.

Based on the system calibration flight line, any alignment errors can be computed and corrected in the processing. The LIDAR elevation point data is projected to XYZ coordinates. First the data is edge matched in order to provide a seamless data set for further processing. Following verification of the daily calibration flight lines, all initial data processing of the LIDAR data is complete.

Ground Surface LIDAR Data Filtering:

All LIDAR points are stored in a database that retains information about flight day and time, return number, laser scan angle, and other information. The database is reviewed and areas of like characteristics are delineated and flagged. The LIDAR processing group will determine which type of filtering techniques need to be applied to each type of area, to provide the best quality at ground elevation surface. Factors that affect this decision are slope, vegetation and cultural features. Each project has unique characteristics that can only be assessed after the data is collected. Data integrity is assured after visualizing results from the selected filtering techniques such as shaded relief models, 3-D viewers and elevation images.

All LiDAR data processing followed the USGS Version 13 Base LiDAR Specifications. Surdex used a combination of automated and manual filtering techniques for the creation of the bare-earth surface. A minimum 95% of the artifacts, outliers, voids, systematic and random errors, noise, anomalies, manmade features and vegetation were removed. The resulting digital terrain will support production of 2' contours for ASPRS Class I Standards. The final step involves output of data into LAS version 1.2 format into two projections. All final LAS data were projected into the following: Nebraska State Plane Coordinates (2600) NAD83, NAVD88 Geoid09, US feet.

Create Hydro-Flattening Breaklines

Surdex has a wide variety of tools available for the compilation of breaklines required for the hydro-flattening services. Surdex's R&D staff has developed proprietary software to assist and improve efficiency in the hydro-flattening process. Several sets of data are available to assist the technicians in developing the hydro-flattening breaklines. These data, including; LiDAR data, color hill shade maps derived from the LiDAR data, NHD, intensity images and current existing imagery are all useful in developing hydro breakline data. Surdex has proven that using color hill shade data in ArcMap is superior for both accuracy and efficiency in breakline compilation in that hill shades provide a much more intelligent representation of the bare earth surface allowing for precise determination of hydro features.

Using the developed hill shades, GIS technicians digitized breaklines on only water features consisting of ponds/lakes greater than ~2 acres and streams/rivers wider than ~30 feet. To improve efficiency, the various data sets described above may be used as a guide directing the technician to areas containing hydro features and providing confirmation of the features as determined in the hill shades. The hydro-flattening is applied to ponds, again using Surdex proprietary applications, by converting the 2-D breaklines to 3-D lines. These data are then draped over the bare earth data and at the discretion of the technicians, based on terrain relief, to apply either a "lowest elevation" or "average elevation" to the 3-D breakline.

Hydro-flattening of streams and rivers is similar to impoundments in that the initial compilation is again derived from the hill shades as described above. Technicians compile 2-D breaklines at the edges of rivers and streams using techniques and resources as described above. For impoundments, however, rather than applying an average or lowest point elevation to the breaklines, technicians compile a profile centerline to be used in determining elevation. The 3-D shapefile centerline is processed through the Surdex application applying elevations to the breaklines at vertices perpendicular to the centerline creating 3-D breaklines. By applying consistent elevations to both sides of the rivers/streams, hydro-flattening produces a level surface perpendicular to the stream in the correct direction of flow. All breaklines will be delivered as PolylineZ or PolygonZ features compatible with GIS and CAD software.

Create Digital Elevation Models

The final Digital Elevation Models (DEM) were created once the data had been calibrated, edited and filtered using our workflows described above. This DEM represents the ground surface, interpolated using the gridded network from the bare earth surface. Water Bodies (ponds and lakes), wide streams and rivers, and other non-tidal water bodies will be hydro-flattened within the DEM.

Hydro-flattening was applied to all water impoundments, natural or man-made, that are larger than ~2 acre in area (equivalent to a round pond ~350' in diameter), to all streams wider than ~30', and to all non-tidal boundary waters bordering the project area regardless of size. Areas outside survey boundary shall be coded as "No Data". Internal voids (e.g., open water areas) will be coded as "No Data" and placed into another class of data so the raw data is available for future use, if so desired.

All final ESRI Grid DEM files and hydro data were generated into the following projection: Nebraska State Plane Coordinates (2600) NAD83, NAVD88 Geoid09, US feet.