PROJECT PLAN

Project:	Missouri / Arkansas Counties LiDAR
Delivery Order No.	0018
Contract No.:	W912P9-10-0538
Date:	2-January-2014
Submitted by:	Wade Williams, Project Manager

US Army Corps of Engineers, St. Louis District

Project Plan

Summary

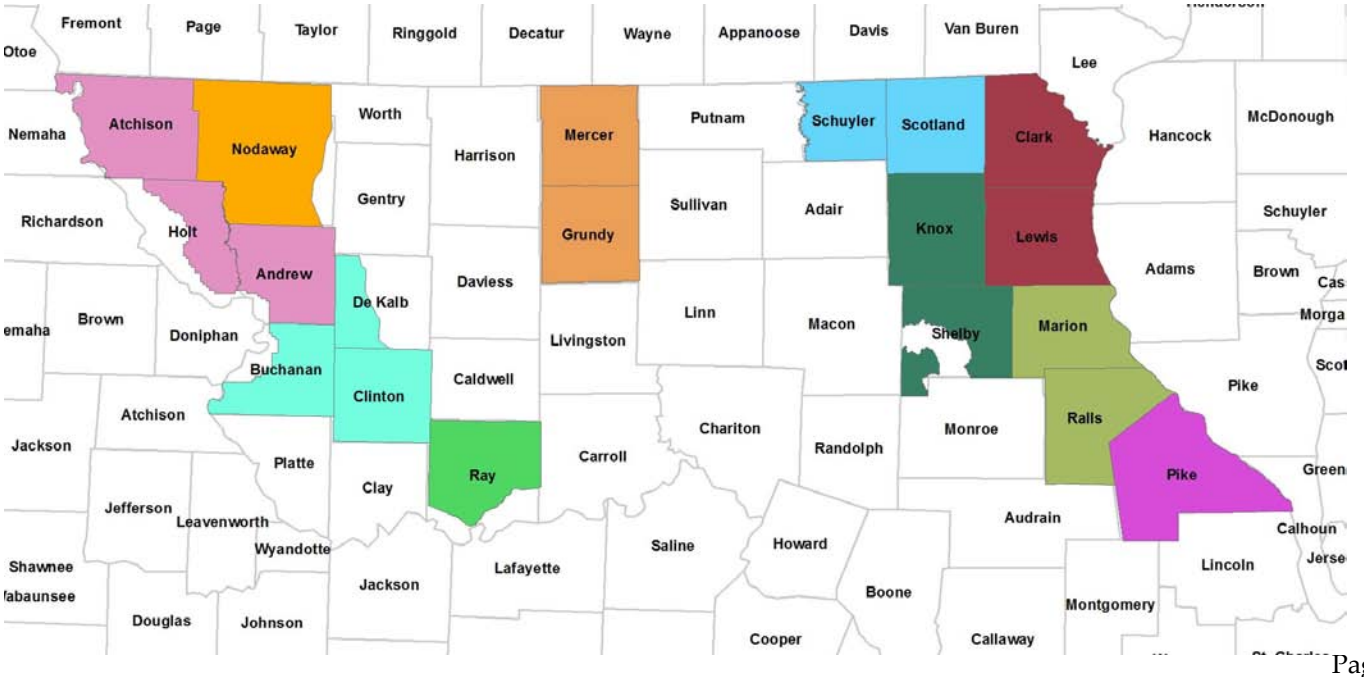
Surdex has read and understands the requirements of the scope of work provided by the NRCS Missouri, USGS-Missouri, USGS-Arkansas, USACE Memphis District, -and MODNR. Surdex will provide the services to meet the required deliverables as defined in the scope of work. This project plan outlines the deliverables and the specification used to complete the project.

Surdex will produce high-resolution digital elevation model developed from LiDAR data as well as hydro-flattened breakline collection. This data will be used to generate digital elevation models and contours for use in hydraulic/hydrologic models and other purposes to include conservation planning activities and environmental assessments. The project is divided into 2 geographic regions over northern Missouri & southeast Missouri along the Mississippi River & into western Arkansas. The northern Missouri areas will be flown at 1-meter spacing covering approximately 8,497 sq miles over Atchison, Nodaway, Holt, Andrew, Dekalb, Buchanan, Clinton, Ray, Mercer, Grundy, Schuyler, Scotland, Clark, Knox, Lewis, Shelby, Marion, Ralls & Pike Counties. The southeast Missouri & western Arkansas areas will be flown at 0.7-meter spacing covering approximately 8,163 sq miles over Cape Girardeau, Stoddard, Butler, Mississippi, New Madrid & Pemiscot (Missouri) Counties and numerous partial Arkansas Counties along the Mississippi and St. Francois River basins. LiDAR elevation data will be collected when the leaves are off trees and will insure the project is also flown snow free and when water bodies are at normal or below water levels.

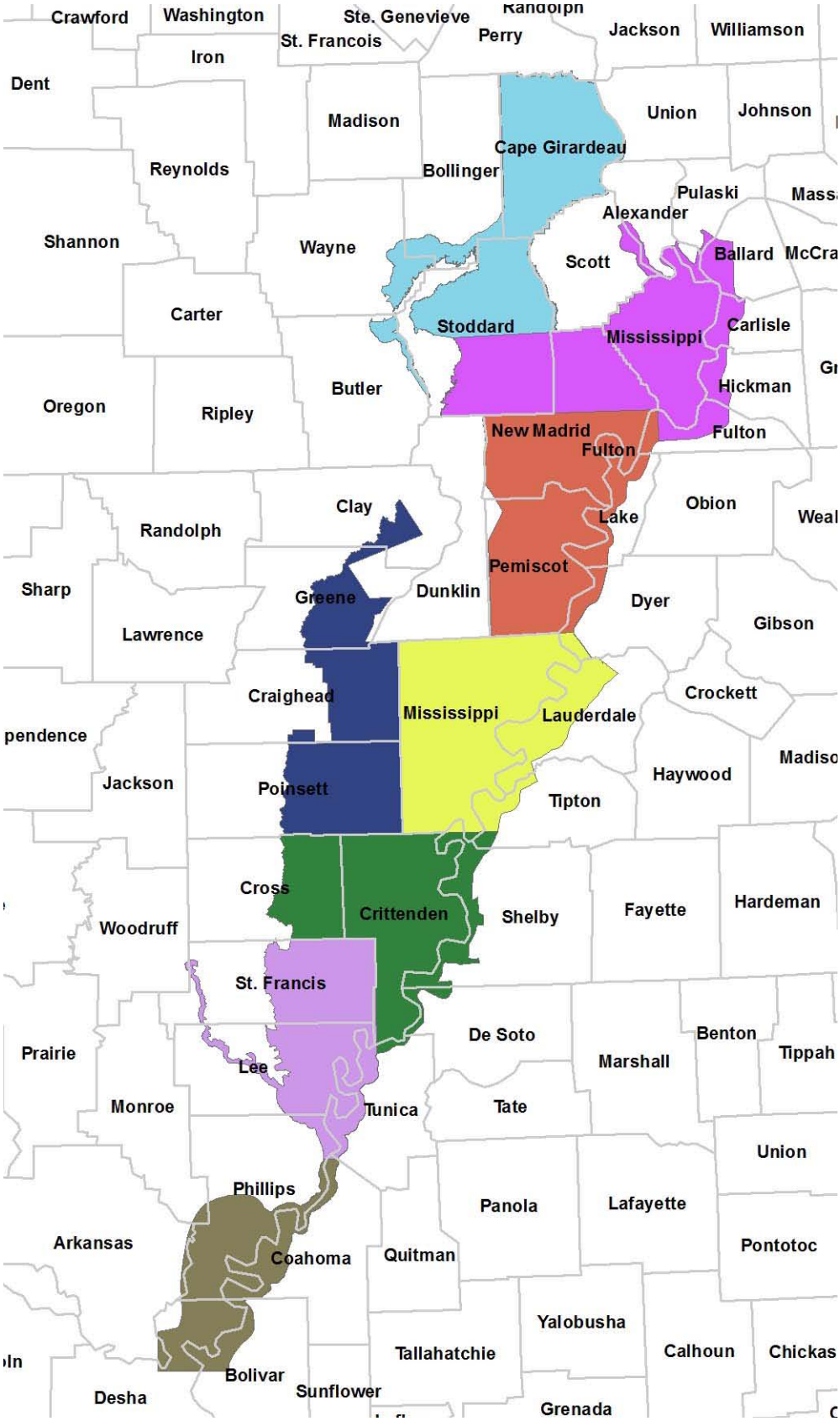
All deliverables will meet vertical and horizontal accuracy as stated in the US Geological Survey National Geospatial Program (NGP) Base Lidar "General" Specification, Version 1.0. Field ground survey points will be collected to control the LiDAR swath data and independent check points will also be collected to QC the final deliverables. Data for this project will be provided in the following coordinate system: UTM NAD83 Zone 15, NAVD88 Geoid12A, meters.

Project Boundaries

Northern Missouri

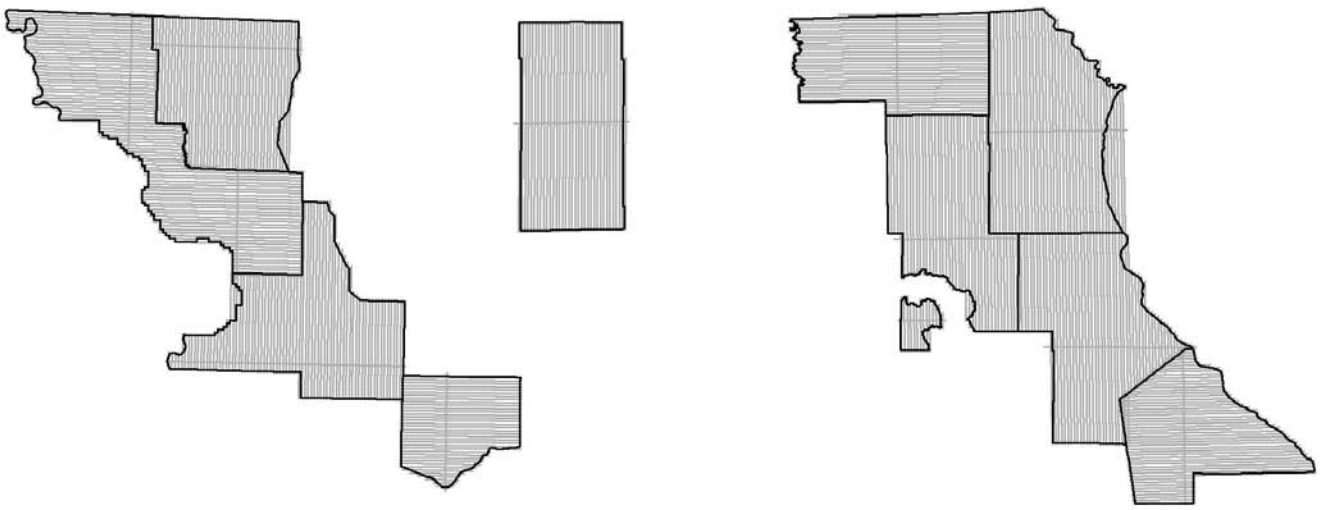


Southern Missouri & Western Arkansas



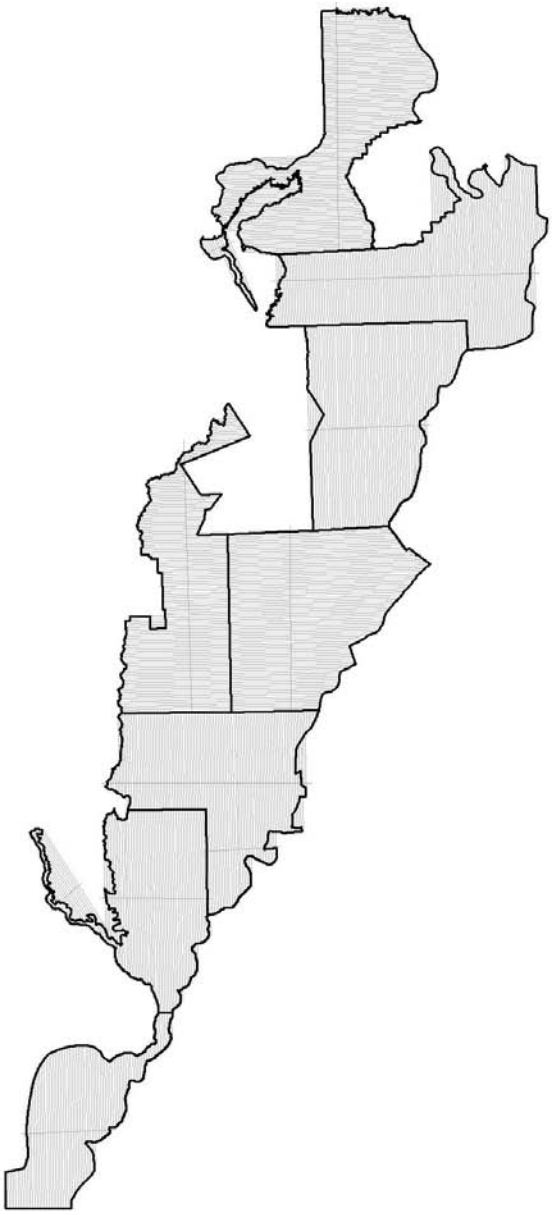
Northern Missouri flight parameters & planned lines:

LiDAR Sensor	
Flying height	1,850 meters AGL
Airspeed	150 kts
FOV (field of view)	40 degrees
Pulse Rate	289,600 hertz
Single Pulse/Multiple	Multiple Pulse
Scan Rate	42.9 hertz
Average Point Spacing	0.9 meters
Base Station Length	25 miles maximum



Southern Missouri & Western Arkansas flight parameters & planned lines:

LiDAR Sensor	
Flying height	1,400 meters AGL
Airspeed	120 kts
FOV (field of view)	40 degrees
Pulse Rate	383,800 hertz
Single Pulse/Multiple	Multiple Pulse
Scan Rate	51.4 hertz
Average Point Spacing	0.60 meters
Base Station Length	25 miles maximum



Lidar Post Processing

All the LiDAR data will be processed through the Leica post processor to generate raw LAS files. These raw files will be loaded into GeoQue and further processed with TerraScan software. An automated bare-earth processing method will be followed by interactive manual edits to clean the data to the best bare-earth removing 95% or greater of artifacts, outliers, voids, systematic & random errors, noise, anomalies, manmade features & vegetation. All post processing will follow USGS National Geospatial Program Base LiDAR Specification, V1.0.

Once accomplished, a color ramped elevation surface will be generated. This color ramped elevation service will be utilized within ArcGIS to manually digitize hydro breaklines into the LAS files. These flattened breaklines will be added to the LAS & DEM to assure the basic flow of the elevation data.

Lidar Deliverables

Surdex will produce your mapping project using the following:

Lidar: 1.0 meter (northern MO) & 0.7 meter (southern MO & western AR) or better cleaned to bare earth

Lidar Format:

Calibrated LAS swath data will be provided for all delivery areas in LAS V1.2 format. Swath files will be split into segments and be 2GB or less in size. Unique flight line ID's will be assigned to all LAS swath lines.

All classified points (bare-earth, first return & intensity data) will be delivered in ASPRS LAS V1.2 format. LAS tiles will use the following classes: 1-processed, but unclassified, 2-bare-earth ground, 7-noise, 9-water, 10-ignored, 11-withheld, 12-overlap points shall not be used. Classified LAS V1.2 tiles as bare-earth & canopy (first return) will also include intensity values, flight information (dates & lines) & return values.

Mapping Products: Surdex will collect hydro breaklines following USGS V1.0 guidelines. The hydro-flattened breaklines will be collected for ponds 2+ acres and 100-foot nominal width streams. Hydro breaklines will break at road culvert features and be continuous through elevated bridge structures. These breaklines along with the Lidar data will support the production of 2-foot contours for the 1-meter areas and 1-foot contours for the 0.7-meter areas. All breaklines developed for use in hydro-flattening will be delivered as an ESRI Shapefile PolylineZ or PolygonZ format.

Breakline enforced bare-earth 1-meter pixel size Digital Terrain Model (DEM) in Imagine (IMG) 32-bit floating point, decimal meters format with defined projection will also be provided.

Classified LAS & DEM deliverables will be provided using a butt matched 4,600 meter tile index and custom naming scheme. ESRI Shapefile tile indexes will include file names and acquisition date fields.

ESRI Shapefile of acquired flight lines with date & time fields.

FGDC compliant metadata will be provided for each deliverable product type (LAS, IMG, breaklines) in XML format.

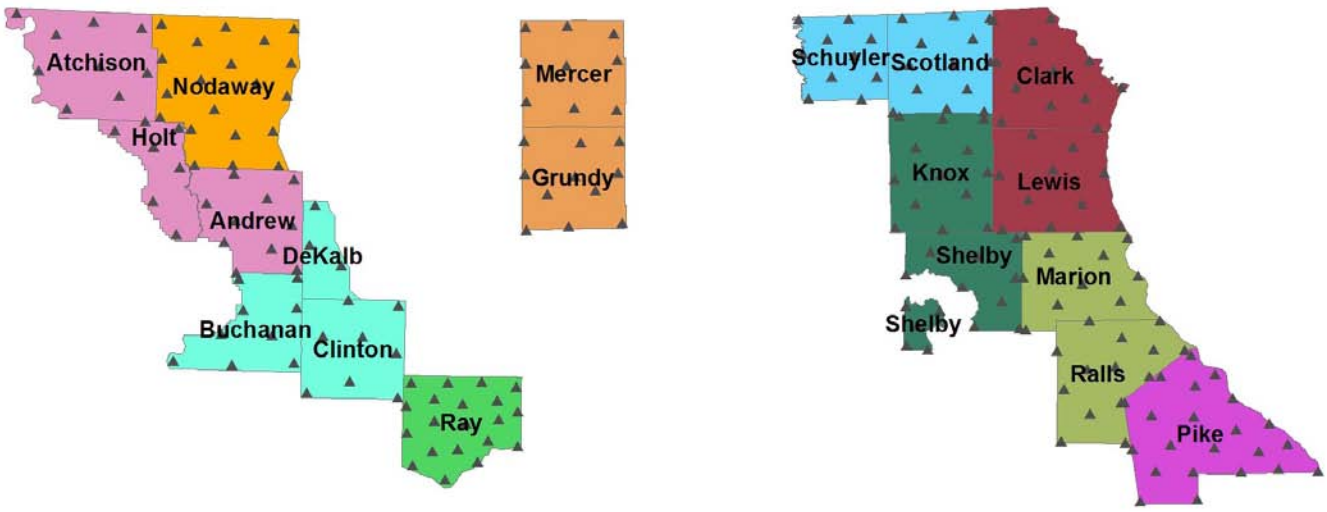
Survey Products & Accuracy: Surdex will test and document that all deliverables meet or exceed standards as stated in NDEP Guidelines for Digital Elevation Data, Version 1.0 for NSSDA of 95% confidence for the appropriate contour interval and ASPRS Class I Standards.

A survey narrative shall be produced in the form of a PDF letter report detailing all aspects of the LIDAR flight, including a description of the fieldwork and detailed office data processing procedures. Surdex shall also provide an interpretation and analysis of the results of the survey, including data quality, coverage of the area, and a summary of the findings.
Surdex will collect ~20 survey ground points per delivery area in order to control the LiDAR swath data, per the graphic below. These points will not be used for the final QA/QC of the LiDAR deliverables.
A USACE approved Surdex subcontractor (Innovative Mapping & Surveying Solutions) will obtain a minimum of 20 independent survey check points in 4 FEMA classes (bare ground, urban, grass/crops, and brush/trees) per ~1,000 sq mile area. These ground truth check points will be compared to the bare earth surface developed from the LIDAR data and meet the following specifications.
The 1-meter collection area will meet 15.0 cm RMSE for Fundamental Vertical Accuracy (FVA).
The 0.7-meter collection area will meet 9.2 cm RMSE for Fundamental Vertical Accuracy (FVA).
In addition, the accuracy of the other land coverage types will be reported according to NDEP/ASPRS methodology which uses the 95th percentile testing method.

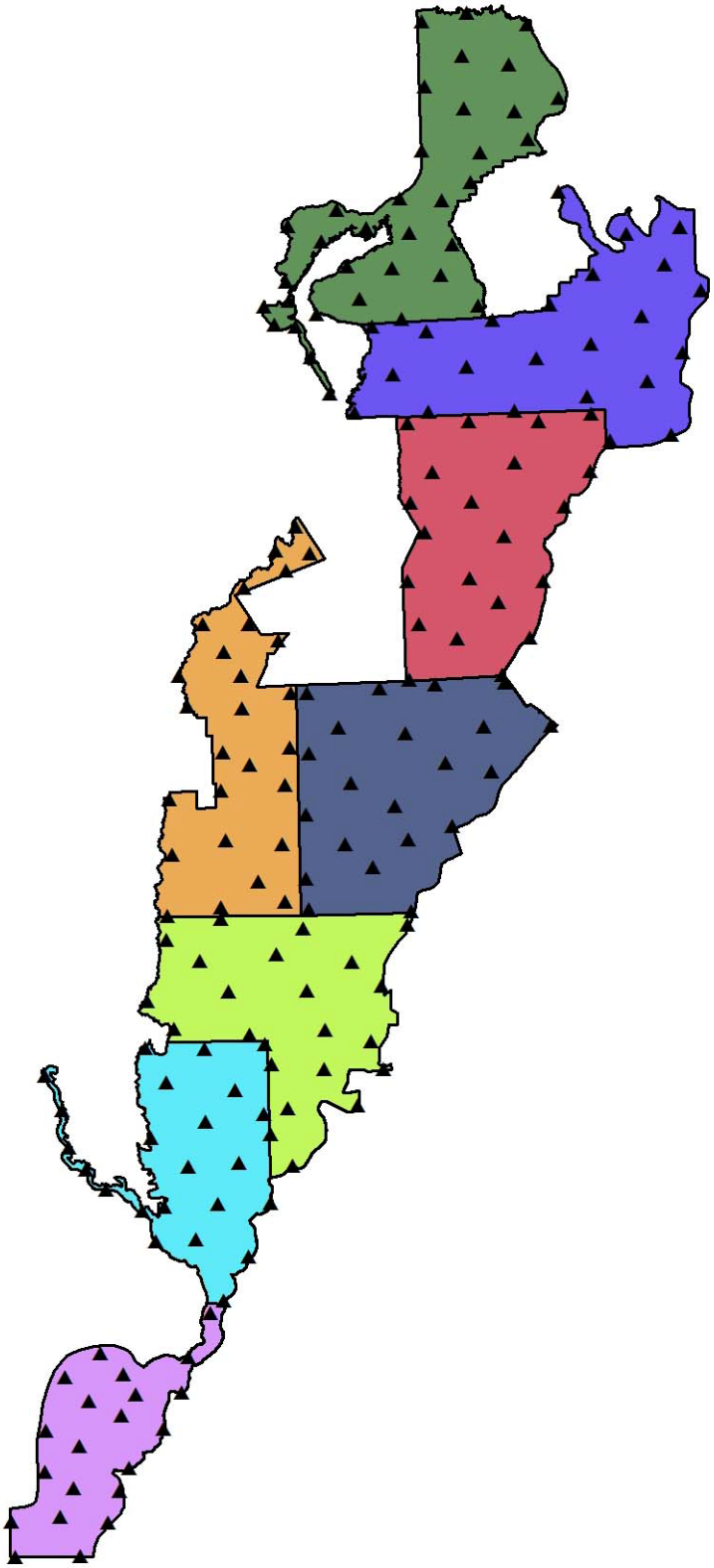
ESRI Shapefiles, ASCII & Excel files will be provided for all LiDAR survey control & check points.

Survey Control Locations

Northern Missouri survey control



Southern Missouri & Western Arkansas survey control



Project Completion Reports

Surdex will provide the following project completion reports and files:

- Ground Survey Completion Report
- LiDAR System Data Report
- Flight Report
- System Calibration Report
- FGDC Metadata

Project Schedule

Surdex anticipates flights & field survey to begin in early December 2013 and flight completion by April 1, 2014. Planned interim deliveries will start in the spring of 2014 and will be dependent on the order of flight acquisition & processing. The preliminary interim delivery areas are listed in the table below. Final interim deliveries will be completed by December 31, 2014.

County	Sq Miles	Delivery
Atchison/Holt/Andrew	1223	3/14/2014
Nodaway	793	3/14/2014
Marion/Ralls	927	4/11/2014
Pike	687	4/11/2014
Buchanan/Dekalb/Clinton	939	5/9/2014
Ray	447	5/9/2014
Mercer/Grundy	892	6/6/2014
Knox/Shelby	896	6/6/2014
Clark/Lewis	1022	7/3/2014
Schuyler/Scott	747	7/3/2014
Cape Girardeau/Stoddard	1117	8/29/2014
Stoddard/Mississippi	1273	8/29/2014
New Madrid/Pemiscot	1123	8/29/2014
Phillips/Desha	640	10/3/2014
St. Francis/Lee	783	10/3/2014
Crittenden/Cross	1073	10/3/2014
Poinsett/Craighead/Greene	949	11/7/2014
Mississippi/Lauderdale	1207	11/7/2014
Totals	**19257**	

Quality Control

The goal of the Surdex Photogrammetric Production Division is to provide the most accurate geospatial data that can be produced for our clients. To accomplish this goal Surdex has established a Quality Control Plan that incorporates the two broad categories of quality assurance and quality checking. Quality assurance encompasses those functional phases of a project that assure the final product will meet the client expectations. Quality checking encompasses those steps performed in the production of a product to physically verify the accuracy of the product. The Quality Control Plan will enable Surdex to generate photogrammetric mapping data that will meet the standards established in the United States Army Corps of Engineers (USACE) Engineering Manual (EM) 1110-1-1000, 01 July 2002, Photogrammetric Mapping.

Quality Assurance

1. **Project Design**
   For each task order, Surdex will communicate with the USACE to discuss products and accuracies that are desired. Once agreed to, the Surdex project manager will develop a Statement of Work (SOW) that outlines the approved products, delivery schedule and price for the task order.

2. **Project Initialization**
   The project manager will develop a project folder from the SOW. This project folder contains the SOW and the work order forms for each of the departments. This process assures that all the USACE expectations are met throughout production process.

3. **Production Processes**
   Surdex has designed its production processes around an ISO 9001:2000 Quality Management System concept. For each of our production departments a best practices document has been developed that defines the current production practices that will assure the highest quality products are produced. Each technician in a department is trained against these processes and procedures. The quality of the final product is assured if these procedures are followed.

Quality Checking

As described above, quality checking is the process of physically checking a product to validate the accuracy. This can be done in the final product and/or it can be done at each of the production steps to validate the final product. At Surdex we incorporate both of these techniques.

1. **Project Design**
   Once the project manger develops a project design it is reviewed by a certified photogrammetrist. This review assures that the design is capable of meeting the client's requirements.

2. **Flight**
   The final flight plan is reviewed by a certified photogrammetrist to assure that it meets the accuracy requirements of the project. The number and arrangement of the ground control will also be evaluated at this time.

3. **Survey**
   The ground control survey design will be generated and approved by a professional surveyor and certified photogrammetrist. All field work and adjustment of survey data will be performed under the direct

supervision of licensed land surveyor. If GPS surveying techniques are utilized, all derived coordinates will be checked against the NGS OPUS results to assure consistency with the national datum.

4. Airborne GPS Data

The Airborne GPS (ABGPS) exposure station control is evaluated on a daily basis to assure completeness and content. Each base station is checked against the National Geodetic Survey (NGS) coordinates through the Online Positioning User Service (OPUS).

5. Flight Status

Surdex maintains an online database of flight status. When a project is initiated, the flight plan is loaded into the database. On a daily basis, the flight crew updates this database with flown exposures. From this database the project manger has immediate status of the flight conditions of any task order.

6. LiDAR Data

LiDAR data sets will be inspected to assure complete coverage of the project area and that no gaps exist. Multiple base stations will be utilized for all flights and comparisons will be made between the various flight paths to assure consistency. Ground truth data sets consisting of survey points from various terrain types maybe employed to validate the accuracy of the final bare-earth DTM surface. Kinematic cross sections maybe employed to validate the accuracy of the bare-earth DTM as well. The methodology for validation of the LiDAR dataset will be discussed and approved by the USACE during task order negotiations to assure the USACE expectations are met in the delivered data.

7. Cartographic Finishing

In cartographic finishing any existing data sets, either DEM, DTM, orthophotography and/or planimetric data are used to verify the new data. If the new data is being incorporated into an existing dataset, all ties to previous data are verified. For ESRI planimetric data sets automatic verifications are performed to check the coverage specifications.

USACE Review

The most important approval in the generation of geospatial mapping products is the approval and acceptance by the Client. The data produced by Surdex can be as accurate as earthly possible, but if the data does not meet the Clients expectations we have failed in our service. To assure that the USACE expectations are met in the production process, Surdex performs the following reviews with the Client.

1. Project Initialization

The final SOW for each task order is reviewed with the USACE to assure that all your data needs are being addressed in the project design. This SOW will include review of the project limits, type of sensor data being collected, a detailed listing of project deliverables and a schedule for delivery.

2. Flight Map Review

The planned flight and ground control maps will be provided to the USACE for review and approval prior to flight.

3. Digital Flight Index

Surdex will provide a digital version of the aerial photography flight index to the USACE for review after the acquisition of the aerial imagery/LiDAR. This image will allow the USACE to review the aerial photography coverage for image quality and coverage.

4. Ground Surveying Report

If any ground control surveying is required for a task order, Surdex will develop a Survey Report that summarizes the control utilized and the accuracy of the derived control points. If monumentation is required, recovery diagrams and digital photos of each monument will be incorporated into this report. This report will be provided to the USACE for review and comment.

5. Pilot Area Delivery

To define the USACE expectations a pilot area will be selected as a first article delivery. This area usually consists of a small portion of the project area that can be used to validate the initial delivery. Some clients like to see the fit between tiles so groups of four tiles are selected at each site. The goal of this Pilot Delivery is to go over the quality, accuracy and data content to assure that the initial processing will meet the USACE expectations. Full production will only proceed after a meeting is held with the USACE to discuss the Pilot data.

6. Pilot Area Meeting

This meeting is held after the USACE has had ample time to review the pilot delivery and assemble their recommendations. It can be held by phone or in person as desired by the USACE. Once approved, Surdex will utilize the pilot dataset as the benchmark to produce all other final deliverable items against.

7. Task Order Wrap-up Meeting

After all the deliverable items have been accepted by the USACE a project review meeting will be scheduled. The purpose of this meeting is to go over the history of the current task, review issues and resolve any outstanding items. The goal is to provide constructive input into improving future task orders with the USACE.