Technical Proposal

Contract Number: OMB-016-GISDATA

SURDEX CORPORATION

FOR PROFESSIONAL SERVICES

TO PROVIDE AERIAL IMAGERY AND LAND USE/ LAND COVER GIS DATA

Miriam L. Pomilio

Office of State Planning Coordination

Office of Management and Budget

122 Martin Luther King, Jr. Blvd. South

Suite 302, Haslet Building, Third Floor,

Dover, DE 19901

Submission Deadline:

Thursday, August 26, 2016 | 4:00 pm

Submitted By:

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Transmittal Letter

August 24, 2016

Miriam L. Pomilio
Office of State Planning Coordination
Office of Management and Budget
122 Martin Luther King, Jr. Blvd. South
Suite 302, Haslet Building, Third Floor
Dover, DE 19901

Dear Ms. Pomilio:

Surdex is pleased to provide this fully-compliant response to "*For Professional Services to Provide Aerial Imagery and Land Use/Land Cover GIS Data.*" We have the expertise, resources, experience, and qualifications to perform to the expectations of the State. All data acquisition and processing will be performed with US labor, ensuring that raw, intermediate, and deliverable data remains within the United States at all times.

We have performed such work for dozens of local, state, federal, and private clients in the last few years, ranging in size from less than 100 square miles to hundreds of thousands of square miles, including recently:

- The State of Texas program in 2014-2015 in which 275,000 square miles of 0.5-meter orthoimagery and over 13,000 square miles of 1'/6" orthoimagery was captured and produced.
- For the 5th consecutive year, Surdex was selected in 2016 by the State of North Carolina to acquire and produce 6"/15cm orthoimagery.
- For the 9th consecutive year, Surdex was selected by the City of Raleigh, North Carolina for orthoimagery in 2016, including annual updates of the planimetric data.
- For the 14th consecutive year, Surdex is acquiring and producing orthoimagery for the USDA National Agriculture Imagery Program (NAIP). We have now produced over 6M square miles of orthoimagery over for 81 state projects covering 32 unique states since 2003. In 2016, our effort includes 400,000 square miles of 60cm resolution, 4-band orthoimagery.

Surdex will use its state-of-the-art Leica ADS100 pushbroom sensor for imagery acquisition. Our five (5) ADS100's represent the largest installation of such sensors in the United States, and we were the first US Company to install and integrate this sensor in 2013. The ADS100 is ideal for this project:

- It simultaneously acquires stereoscopic 4-band imagery from each of three arrays (nadir, forward, and aft).

Company Overview

A. About the Surdex Team

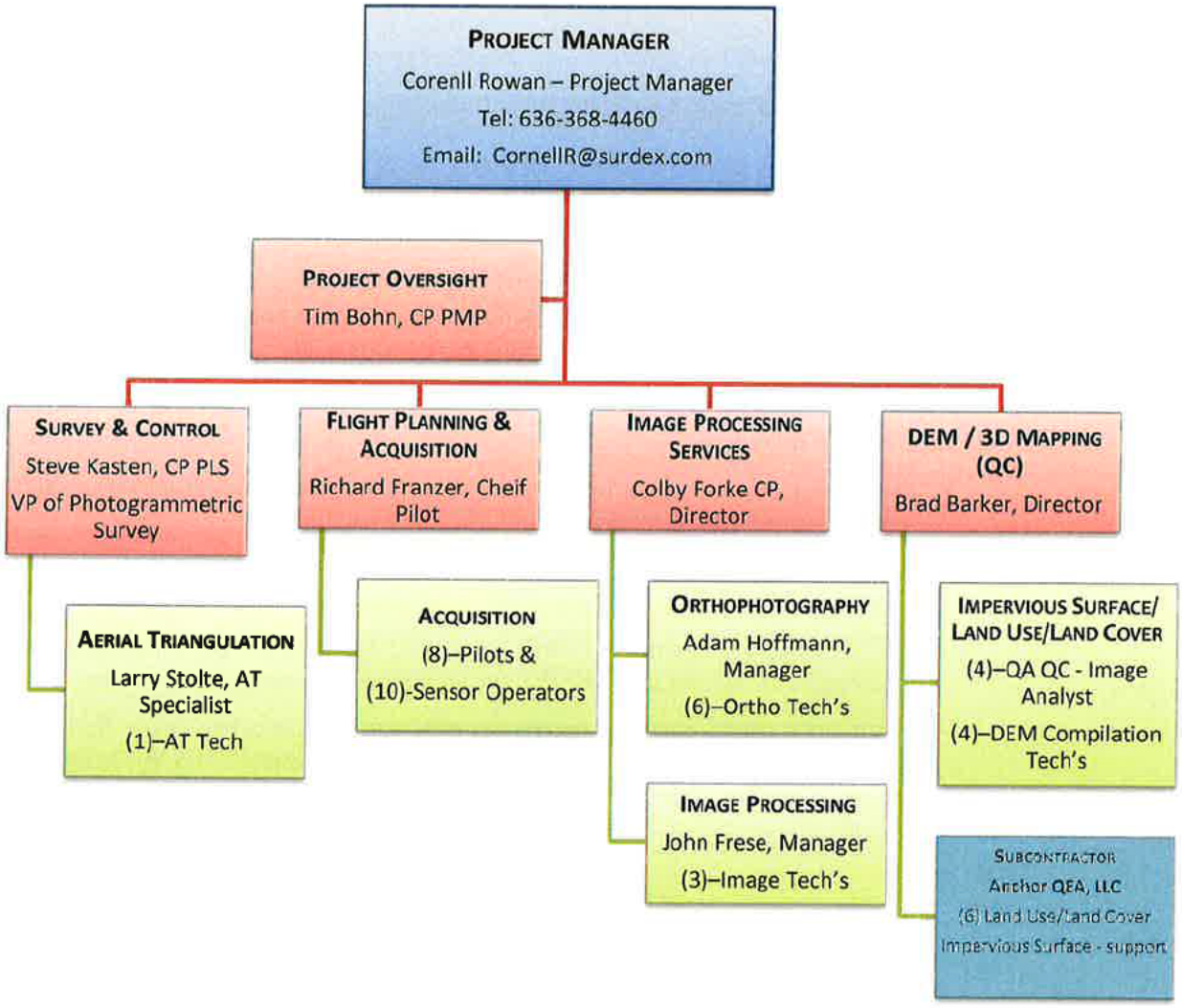
Surdex Corporation

Surdex Corporation is a privately-owned company that has been in continuous operation for over 60 years and is currently one of the 10 largest aerial mapping companies in the United States. We have been based in the greater St. Louis, Missouri, metropolitan area since 1954. Over the last decade we have grown from a regional company to a nationwide presence, including projects in Canada and Mexico. Approximately 90 employees work at our headquarters building and hangar complex at the Spirit of St. Louis Airport in Chesterfield, Missouri. Our clientele include federal, state, and local government as well as private engineering, defense mapping, and Homeland Security. Our success can be attributed to our:

- **Experienced and skilled staff**: our senior staff averages 25 years of experience, and our technicians average 9 years. We have over 15 staff who are Registered Land Surveyors and/or ASPRS-Certified Photogrammetrists, and a number of these have advanced degrees.
- **Aerial sensors:** Surdex has eight large-format digital imagery sensors (five Leica ADS100s, three Leica DMCs, oblique and medium format digital sensors (six Leica RCD30s configurable as separate, five head, or three head), as well as a Leica ALS70 LiDAR sensor.
- **Aerial acquisition:** Surdex boasts a fleet of ten aircraft supported by our own staff certified by the FAA for inspection, maintenance, and repair to ensure maximum availability. Our premier imagery acquisition aircraft is the twin-turbine Cessna 441 (Conquest), which can operate up to 35,000' and cruise at over 300 knots.
- **Digital Orthoimagery:** Surdex's processing environment consists of open source, 3rd party and custom-developed software supported by our Enterprise database, all operating within a distributed processing environment and under a common user interface. We support all standard file formats such as TIFF, GeoTIFF, MrSID, JPEG, and JPEG2000.
- **Extensive successful experience**: Surdex has been awarded, through competitive processes, some of the largest projects in the nation, including the 275,000 sq. mi. statewide digital orthoimagery project for the State of Texas and over 6 million sq. mi. of orthoimagery for the USDA National Agriculture Imagery Program over the past 14 years; existing contracts with the Army Corps of Engineers; a current USGS GPSC contract; and numerous state and local government repeat clients.
- **Web-Based Client Product Inspection Tool**: Our SurCheck℠ tool streamlines the inspection, remedial action, and acceptance process and has been in use for over five years by many of our clients.

Select Recent Applicable Orthoimagery Project Experience					
Project	Client	Year(s)	Resolution	Scope	Client Point of Contact

[redacted]



Surdex's project management approach is founded on providing relevant information backed by frequent communication. Each of our project managers has experience in nearly all phases of production and most are Certified Photogrammetrists. They are guided by the philosophy that they must support the objectives of their clients and manage internal resources to meet these objectives.

Communication can take the form of face-to-face meetings, e-mails, telephone calls, faxes, webcasts, etc. Our project managers are required to communicate with each of their clients at least once each week and are required to respond to a client's communication within 24 hours of receipt.

imagery and LiDAR. It also includes extensive tracking of aerotriangulation, DEM development, digital orthoimagery, planimetric and topographic mapping, QC and delivery. During the critical acquisition phase, acquisition will be reported daily via graphical and textual reports. Since image inspection occurs in parallel with acquisition, every day entails an update on inspection status and the possibility of isolating re-flights.

If desired, a password-protected SharePoint site containing all information about the project can be supported. Content can include project documents such as:

- Contractual documents, including specifications.
- Status reports delivered to the client.
- Graphical and textual representations of project status: acquisition, processing, QA/QC, delivery, etc.

Upon completion of each project, the Project Manager and the business development representative are required to assess the client satisfaction. These results are tabulated and provided to Surdex's Executive Team as well as posted to all employees.

B. CAPACITY

Surdex has evaluated our current and projected workload commitments and assures that it has more than sufficient capacity to undertake this project, ensuring our ability to meet project schedule demands and quality. Surdex maintains a schedule of resources for each project that is reviewed and updated at least bi-weekly by department heads and project managers. This continual assessment of our workload allows us to isolate issues and deal with each as required – such as additional overtime, re-assignment of cross-trained staff, and potentially reaching out to trusted subcontractors.

Our estimated level of effort, assuming acquisition and processing of the entire State in 2017 at 25cm resolution is as follows:

- The acquisition effort is estimated to require less than 5% of our total resources for the spring period of 2017.
- The orthoimagery production effort is estimates to require less than 5% of our total resources for the spring/summer period.
- The LULC and impervious surface update requires less than 5% of the Surdex and Anchor resources.

Scope of Services

Below is a summary of the orthoimagery requirements and specifications.

Aerial Orthophotography		
Criteria	Minimum Specifications	Upcharge
Coordinate System	DE State Plane (meters)	
Datums	NAD83, NAVD88	
Resolution	1/4 Meter	Higher resolutions
Bands	4 Band	
Vegetation Conditions	Leaf off	
Water Conditions	Normal water (no flooding)	Tide coordinated
Cloud Cover, Smoke, Haze, Snow	None allowed	
Sun Angle	Greater than 30 degrees	
Ortho Tile Grid	1700m x 1700m	
Ortho Tile Submission	Provide an ESRI geodatabase	
Metadata	Project level	Feature level (tile level)
Deliverable Media	External hard drive	
Deliverable Image Format(s)	GeoTIFF and MrSID	GeoTIFF, MrSID for tiles JPEG2000 for mosaics
Flight Line Overlap (Edge Overlap)		Increased overlap in urban areas, to reduce building lean
QA/QC	Independent 3rd party	
Collection Frequency	2 years	

A. AERIAL ORTHOPHOTOGRAPHY

This section details the general steps taken in the acquisition of imagery and production of digital orthoimagery.

PROJECT DESIGN

The project design is driven by the deliverable tile layout and a buffer around the boundary and includes a flight design and a control survey design. Flight planning is the responsibility of Surdex's Chief Pilot and is reviewed and approved by the Project Manager. The Aerotriangulation and Survey Departments design the ground control network against the flight plans. A Certified Photogrammetrist from Aerotriangulation and a Registered Land Surveyor are responsible for the design.

These steps provide additional imagery for the technicians to use during the mosaicking process, resulting in most cases of varying views to select from. The following graphic shows an example from the St. Louis area in 2015. In this case, the baseline north-south design (red) was augmented by diagonal flight lines (yellow/tan) and tighter spacing to increase the sidelap.

Excerpt of Flight Plan Addressing the Built-Up Areas in Downtown St. Louis.

To properly assess our acquisition resource requirements, we designed a preliminary flight plan for the state at ¼ meter (25cm) resolution. This resulted in the following key metrics:

- 29 flight lines.
- Approximately 1,357 total Flight Line Miles (FLM).
- Approximately 10.8 hours of on-line acquisition.

No additional lines were added for built-up areas (BUAs) to reduce building lean, but this is expected to add only 1-2 hours. Thus, the total acquisition time would be approximately 13 hours of acquisition.

AIRCRAFT

Surdex is widely regarded by clients and colleagues as one of the premier aerial acquisition companies in North America.

- We have an all-Cessna fleet, standardizing maintenance, repair, inspection, and operation.
- We can host each of our acquisition instruments (film and digital sensors, LiDAR).
- We have a mix of slower/lower and faster/higher aircraft to maximize our resources.

Our aircraft are based at Spirit of St. Louis Airport, only blocks from Surdex's headquarters in the St. Louis area. From this with this centralized location, we can efficiently handle projects throughout North America.

Surdex's Acquisition Aircraft For This Project

No.	Aircraft Type	Category	Specifications	Image
4	**Cessna 441 Conquest II-10 (with RVSM *)**	Twin-Turbine Pressurized	Flight Range: 2,193 nm Altitude: 1,200 - 35,000 AGL Certified Altitude: 35,000 MSL Approximate Cruise Speed: 310 knots	
1	**Cessna 414A Chancellor III**	Twin-Piston Pressurized	Flight Range: 900 nm Altitude: 1,200 - 25,000 AGL Certified Altitude: 30,200 MSL Approximate Cruise Speed: 235 knots	

** RVSM: Reduced Vertical Separation Module. This FAA-certified equipment allows operation above 28,000' (MSL).*

The Cessna 441 (Conquest) aircraft are the highest performing and most versatile aircraft in the fleet. They can fly slow (less than 150 knots) or fast (300+ knots) and stay aloft for up to 7 hours. Their pressurized environment ensures comfortable conditions for the crew as well as a stabilized environment for the sensors. Most importantly, the RVSM equipment and advanced radar allow us to ferry safely at night, whereas most piston aircraft are ferried during daylight hours. Since our Conquests can ferry non-stop to any point in the lower 48 from our home base, they can handle the widely diverse projects during the hectic spring and summer flying seasons.

THE LEICA ADS100 DIGITAL PUSHBROOM SENSOR

Surdex owns five (5) Leica ADS100 Airborne Digital Sensors, one of the industry's premier sensors. Our initial two units purchased in the summer of 2013 were the first such instruments installed in the United States. Since that time we have purchased three (3) additional units, making our installation the largest in the United States and one of the largest in the world.

Having deployed the ADS100 as our primary sensor since late 2013, Surdex-led teams have logged over 500,000 flight line miles and nearly 3 million square miles of coverage.

The stereoscopic geometry is even superior to the 9"x9" film photography relied upon for decades.

- With the telecentric lens design of the ADS100, all light rays strike the focal plane normal to the arrays, resulting in the same radiometric response for all pixels. This avoids the well-known "fall-off" issues at the edge of the exposure encountered by the lenses of conventional frame-format digital cameras, simplifying balancing during the mosaicking step.
- With each band (R,G,B,NIR) in each array collecting at full resolution, features imaged by the ADS100 do not exhibit the blooming and smearing attributed to the pan-sharpening approach taken by virtually every large-format digital frame camera on the market today. This enhances interpretation and results in an aesthetically pleasing rendition of color.
- The spectral responses of the bands do not overlap, promoting ideal automated image classification.

Leica ADS100 installation in a Surdex Cessna 441 (Conquest).

Surdex's Five ADS100 Sensors			
Sensor Make/Model	Serial #	Calibration Date	IMU Make
Leica ADS100	10510	06/21/2013	CUS6
Leica ADS100	10515	07/02/2013	CUS6
Leica ADS100	10522	12/16/2013	CUS6
Leica ADS100	10531	6/12/2014	CUS6
Leica ADS100	10552	04/30/2015	CUS6

Surdex has invested numerous years in the development of a custom Enterprise database, and it is used for all Surdex projects, including LiDAR projects. This database is responsible for tracking the status of deliverables, data acquisition, image inspection, intermediate digital orthoimagery, quality control results, and so forth. It can generate reports required on this contract, such as daily acquisition progress reports.

The database tracks all orthoimages created from the numerous images, allowing it to trace the lineage of any pixel in the project back to its original image. It also retains image metrics for every intermediate and final product generated during production. For example, its relational constructs allow it to determine which Master Tiles, and thus deliverable tiles, can be generated at any time. As such, standard queries can be used to determine which areas can be converted into products. Since the database tracks the completion of Master Tiles and deliverable tiles, complete and detailed status is available at any time.

Software and Tools			
Phase	Tool	Ancillary Tools	Surdex Enterprise Database
Flight planning	Leica MissionPro	ESRI ArcMap Surdex Group Tool PhotoShop Global Mapper	Flight plans Flight data ABGPS/IMU results Image inspection results Aerotriangulation results Image metrics Seamlines Client inspection results
Flight control	Leica FlightPro		
ABGPS/IMU processing	Novatel Inertial Explorer		
Post-processing	Leica XPro		
Image inspection			
Aerotriangulation			
Orthorectification			
Image processing	Surdex Group Tool		
Mosaic			
Accuracy validation	AccuracyAnalyst		
Client inspection and acceptance	Surdex SurCheck		

Surdex's processing uses a heavily distributed processing environment. Coupled with our custom software, each workstation in the facility can be used for processing. Over one hundred workstations are available for use.

Surdex Data Storage Architecture		
Tier	Storage	Comments
Violin Memory StorNext shared SAN	110 TB	Data currently in production. Flash memory better than 400,000 IOPS and 6,000 MB/sec throughput
Infortrend StorNext shared SAN	1 PB	Data currently in production. Drives in a RAID6 configuration.
Windows NTFS Direct Attached Storage (DAS)	1 PB	Raw images – also backed up on LTO6 tapes. The files are distributed across 72 servers and managed by the database
TOTALS	**2.1 PB**	**Does not include local workstation storage.**

Surdex uses a tiered approach to storing data, providing a means to have primary data (data in production) stored on the fastest storage with files migrating down through the tiers to successively slower access as the likelihood of frequent access goes down. This minimizes the need for expensive, high-speed storage and allows us to keep the data on-line longer. Since many processes are compute-bound, this reduces the need for expensive, high-speed disks. Ultimately, all data is backed up to LTO6 tape for long-term storage.

The final adjustment of the network will be fully constrained to a minimum of four NGS horizontal monuments and three NGS vertical monuments. In addition, a minimum of three surrounding NGS Continuously Operating Reference Stations (CORS) sites will be downloaded into the project. The final constrained adjustment will be held to the NGS monuments and all CORS and OPUS solution positions will be evaluated as check-points. Any irregular discrepancies in the final network will be evaluated and resolved. This method of least squares adjustment of the survey network assures a known relationship between the NGS monumentation, CORS, and OPUS solutions within the survey observations.

AERIAL IMAGERY ACQUISITION

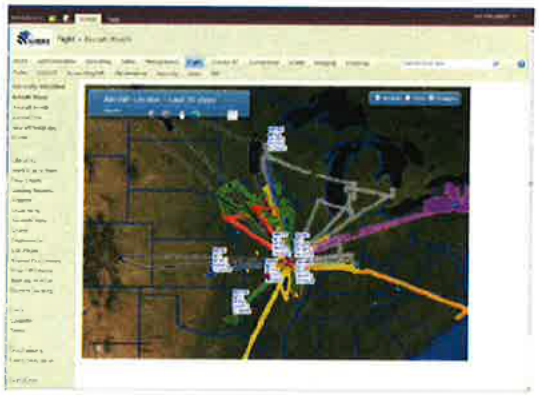
Acquisition of imagery is one of the most critical phases of any project, and successful acquisition relies on an extremely high degree of communication between Surdex's Chief Pilot and all aircrews. Flight plans are updated each evening by merging progress to date with the results of imagery inspection (isolating potential re-flights). These plans reside in the Enterprise database and are distributed daily to aircrews via the Internet and/or e-mail.

Surdex's Chief Pilot will inform the local Air Traffic Control (ATC) and/or military air traffic control authority in advance of flight operations. This includes providing aircraft tail numbers and flight designs to ensure the local authority is fully informed.

For acquisition involving restricted airspaces and/or Military Operations Areas (MOAs), thorough coordination with the Air Traffic Control centers and often military operations centers is required. In such cases, Surdex proactively provides the necessary information, including flight plans, to the proper authorities to ensure trouble-free access to the areas. Surdex has performed acquisition in and around highly sensitive airspaces, such as White Sands Missile Range (New Mexico), Nellis Air Force Base (Nevada), and the Washington, DC ADIZ (Air Defense Identification Zone). Experience has shown that high degrees of communication and adherence to directives results in long term success. In some cases, this has even required that a government official be physically present on the aircraft.

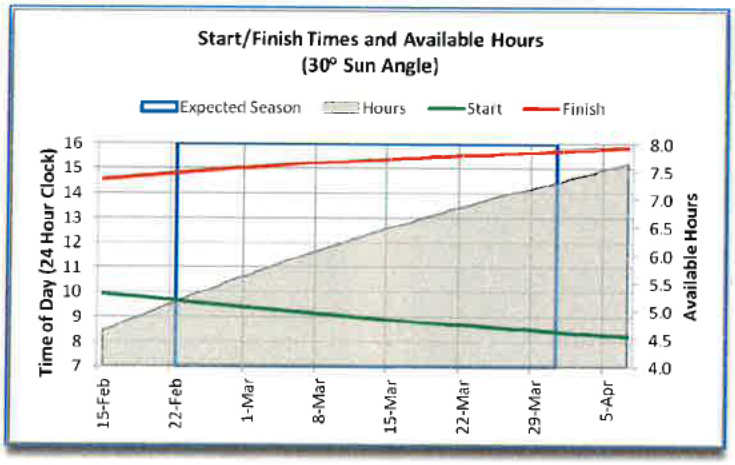
Surdex has customized internal applications that allow the viewing of the aircraft status in various ways.

Surdex continuously tracks our aircraft on our internal SharePoint site.



Should re-flights be necessary, Surdex will prioritize them to be acquired as quickly as possible after the initial flights. By doing so, differences in ground conditions are minimized to ensure re-flights can be blended into the original flights during production. If the re-flight is not a full line, it will include full stereoscopic overlap with the remaining portions of the line.

Based on the assumption of the acquisition of 25cm imagery over the entire state in the approximate timeframe of mid February through late March under a minimum 30° sun angle, the following chart illustrates the available acquisition hours.



This amounts to approximately 230 hours of available time, ranging from 5.2 hours to 7.3 hours through the period and averaging approximately 6 hours. This compares to our estimated resource requirements of at most 13 hours based on preliminary flight plans for 25cm resolution. Surdex's experience is that we average around 4 hours of acquisition on a given day and that acquisition happens on approximately 25% of the days. Therefore, we estimate that only 3-4 days would be required for a single aircraft.

Hand-in-hand with image inspection is the processing of ABGPS/IMU data, which is critical for pushbroom cameras to support image reconstruction. Surdex uses the standard Leica workflow to capture and process the ABGPS and IMU data. The ADS100 carries the Novatel SPAN GPS/GNNS inertial navigation system in the aircraft. Surdex uses Trimble R8 model receivers to collect ground base station GPS and GLONASS data during each flight. The position of the ADS100 sensor and the GPS antenna are measured within the coordinate system defined by the central axis of airplane. These measurements along with the GPS and IMU data captured on each flight are processed using Novatel Inertial Explorer software. Inertial Explorer produces a differential solution for the airborne positions and attitude more than a hundred times a second for the duration of the flight. As the Leica ADS100 is a line scanner there are no individual stations, but rather a stream of epochs or fixes are produced at a rate of 128 per second. Only during aerotriangulation are discrete fixes calculated at a spacing dictated by image measurement density.

Analytical Aerotriangulation (AT)

AT is ultimately responsible for the foundation accuracy of the project and for this reason it involves checks and balances to ensure accurate data is made available to the entire production process to avoid costly and time-consuming re-work. Using ABGPS/IMU data coupled with ground control, the position and attitude information of the imagery is refined to make possible the accurate geopositioning of any point on the ground. The inputs to AT are:

- ABGPS/IMU data.
- The imagery.
- Ground control points and any check points.

The AT process involves:

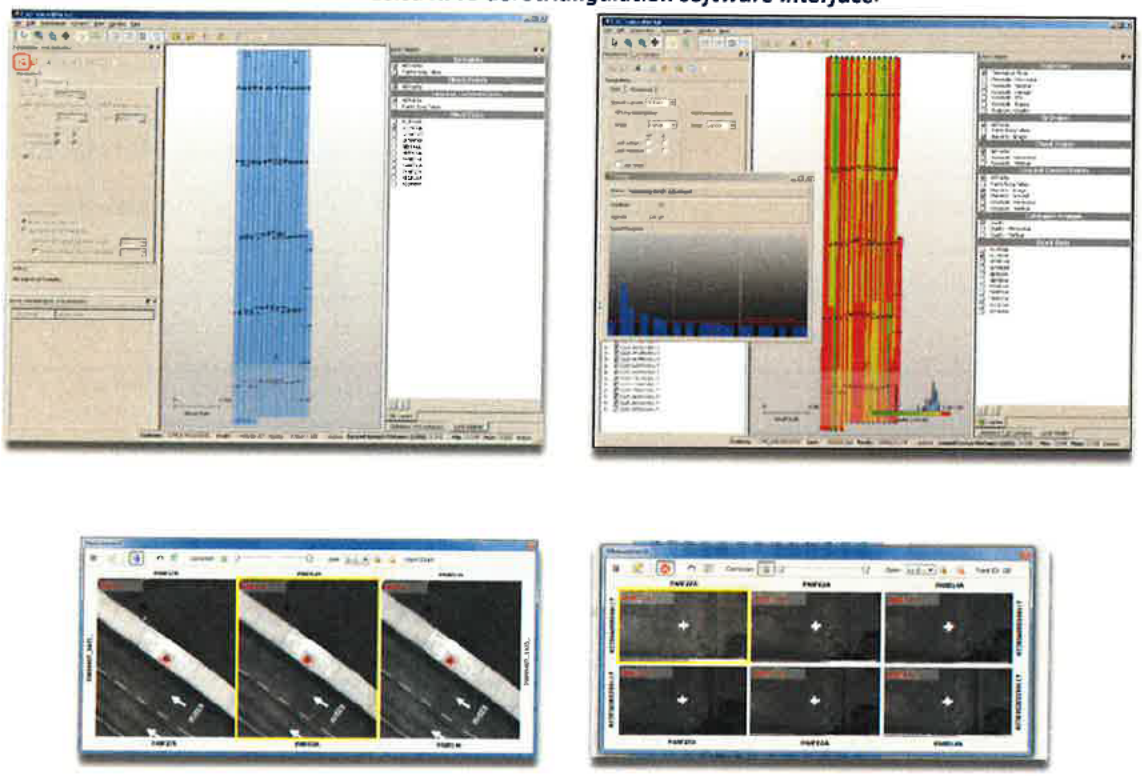
- Automated measurement of pass and tie points appearing in the overlaps of the imagery.
- Interactive editing of pass and tie points.
- Measurement of control and check points.
- Solution of the refined imagery position and attitude as well as all point positions.
- If required, re-measurement of points and repetition of the solution.

The AT solution involves a sophisticated "bundle adjustment" using the method of least squares and a mathematical model of the imaging sensor geometry. This includes utilizing the results of the "boresighting" of the sensor (relative position of the lens to the GPS antennas and relative orientation to the IMU) and synchronization with the ABGPS signal.

The bundle adjustment relies on the use of far more "observations" (initial, observed/recorded values such as ABGPS, IMU, ground control, and image measurements) than are required for a unique solution and because of this employs a least squares optimization approach in the solution. Each observation is "weighted" based on its estimated accuracy to provide a balance in the optimization. Since there are far more observations than required, careful inspection is made of the various "residuals" reported by the solution. For example, an ABGPS position residual is the difference between the final adjusted value and the initial value from ABGPS

matching and manual editing that must be performed. Additionally, the trajectory model ensures cohesive and accurate results within each strip.

Leica XPro aerotriangulation software interface.



A bound report on the aerotriangulation process can be provided at the completion of each block and will be written by a Certified Photogrammetrist. This will address, at a minimum, the following items:

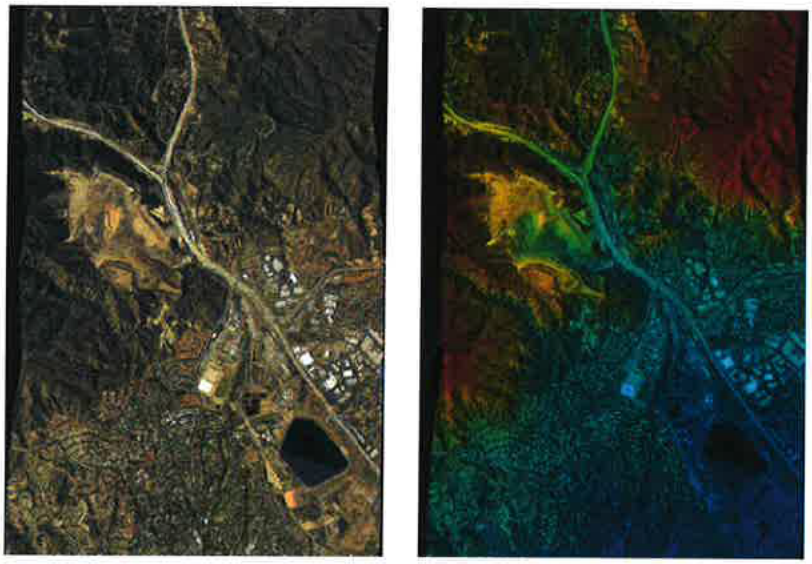
- Coordinates and residuals for all points.
- Coordinates as specified in the project design parameters.
- Description of control points and check points used in the process.
- RMS values and projected ground elevation accuracy for all points.
- Delineation of discarded points and rationale.
- Summary of statistics generated for the final bundle adjustment.

We use several approaches to ensure the elevation model is accurate and current enough to support the digital orthoimage accuracy requirements:

- Visual review of the elevation model for detection of obvious artifacts (e.g.: relief-shaded views, color-coded elevation views, etc.).
- Comparison of aerotriangulation points with the elevation surface. This allows technicians to more closely review "suspect" areas where vertical discrepancies exist between the surface and the AT.
- Visual review of orthoimage products.

If significantly large areas require an update, we often use the Leica Semi-Global Matching (SGM) software. This approach yields very high integrity surface models by essentially matching every pixel in the forward, aft, and nadir arrays to create a "photogrammetric point cloud."

Surdex SGM results with ADS100: image drape (left) and color-coded heights (right).



The pushbroom technology offered by the ADS100 streamlines production, especially in situations around elevated structures such as overpasses, bridges, etc. that are not typically represented in bare earth elevation models. Such features generally require a localized surface elevation model to ensure accurate portrayal. However, since many features are captured in a near-nadir fashion by the ADS100, this additional production effort is not always required.

Features and Benefits of Surdex's Orthoimagery Production Process	
Feature	**Benefit**
Image color, tone, balance, etc. prototyped before production begins in a Pilot Project.	Client participates in desired appearance of final product far in advance of delivery. The pilot project also checks form and format of deliverable imagery, metadata, etc.
All image processing and production performed in "4x12" space (4 bands, 12 bits/pixel) until the cutting of deliverable image tiles: (1) Generate color, 4-band, and/or color infrared (2) 8 or 12/16 bits per pixel deliverables	Preserving full content provides maximum latitude in mosaicking process. Ensures highest possible quality products.
Internal production tiles are in a contiguous (seamless) format, with deliverable tiles generated at the final stage. This supports: (1) Overlapping deliverable tiles (2) Multiple deliverable tile layouts (3) Multiple map projections (4) Multiple product resolutions	Accommodates clients with requirements for multiple layouts of deliverable products at marginal additional cost. Accommodates last-minute changes. Edits to data only done once to support multiple products.
Highly automated absolute radiometry and atmospheric processing, reduces: (1) Level of subjectivity by technicians (2) Production labor effort (3) Changes to be made in final stages of production	Higher volume and throughput.
Customized seamline generation process: (1) Highly effective (2) Inclusion/exclusion areas (such as building footprints)	Seamless final product. Reduced customer review.
Proven ability to incrementally produce large orthoimagery projects while preserving a seamless appearance at completion.	Allows incremental QC and delivery to address client priorities, leveling of QC resources, and schedule compression.
Enterprise database underlying all imagery and data.	Complete lineage of all processing. Automated generation of FGDC-compliant metadata.
Web-based QC tool available free-of-charge for clients: (1) Reduces cost and time associated with multiple deliveries of hard drives (2) Fast turnaround of fixes and validation of fixes (3) Progress tracking	Accelerates QC and acceptance process. Audit trail of all changes. Reduces time for customer QC.

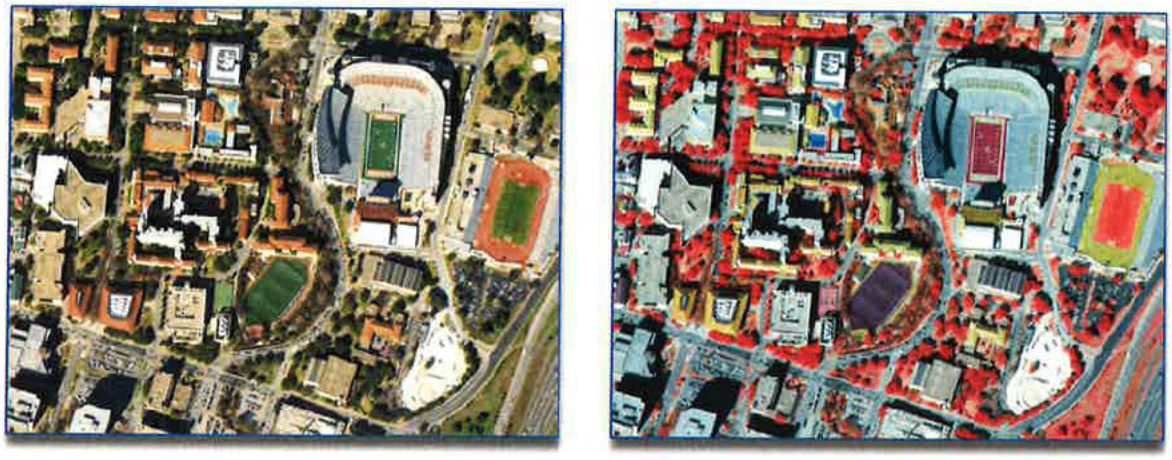
Using Surdex's Group Tool, image processing technicians organize large blocks of orthoimagery into groups with common characteristics – not necessarily coinciding with individual flight missions. The tool can display images in ground space, allowing operators to see the relative image quality between neighboring images. Imagery can be viewed in either color or CIR to ensure 4-band continuity. The grouping of images is important because:

- The atmospheric conditions during capture may result in imagery covering regions of differing degradation caused by haze. This is particularly true in coastal areas.
- Sun movement during the day affects the direction of sun illumination. Understanding this allows efficient solar corrections of groups with common illumination effects.

There are distinct steps in the image processing phase:

- Grouping of image strip blocks and initial color corrections with a simple gamma correction (brightness and contrast)
- Atmospheric corrections based on radiometric calibration of the sensor

Color (left) and CIR (right) renditions of a 4-band file (University of Texas, 2015, 0.5-meter GSD).



Orthorectification

Orthorectification will be performed using the Leica XPro software. The orthorectification process employed by the XPro software includes a ray trace from a ground coordinate to the pixel. All resampling is performed using bi-cubic resampling to assure pixel location accuracy and avoids aliasing effects common to nearest-neighbor and even bilinear resampling techniques.

Mosaicking

Mosaicking encompasses two fundamental phases: (1) editing of artifacts and creating seamlines to stitch the raw orthoimages together and (2) balancing of the imagery to provide a consistent appearance of the imagery (color, tone, brightness, contrast, etc.) associated with the desired appearance determined in the Pilot Project. Mosaicking inputs are the raw orthoimages along with shape files that guide editing of specular reflection and obscured/smeared areas. Once all seamlines are finalized and balancing complete, the Master Tiles are generated to support the generation of the deliverable tile layouts.

The mosaicking steps are:

- Editing of occlusion or smearing caused by rugged terrain.
- Specular correction.
- Seamline generation.
- Global balancing.

Editing of Occlusion and Smearing

Surdex has developed a custom software module to detect potential occlusions and smearing that may occur in rugged terrain. This software creates a shapefile that directs technicians to examine pixels that may require correction. If correction is required, corresponding imagery from overlapping orthoimagery is inserted to replace it during the mosaicking process.

Initial automatic (left) and manually-adjusted (right) seamlines.

Surdex will supply an ESRI shapefile that fully delineates the seamlines. Our custom software automatically generates the seamline data during production, made possible by our software integrating automatic seamline generation and interactive edit into a single application and interface. Each orthoimage merged into the mosaic is defined by a polygon representing its bounds with each of its overlapping neighbors. The polygon attribution contained in the shapefile includes:

- Date of acquisition.
- Polygon start/end date/time.
- Spectral resolution (color, CIR, 4-band).
- Sensor manufacturer and model (e.g.: Leica ADS100).
- Sensor serial number.
- Aircraft type and tail number (e.g.: C441, N2NQ).
- Average flying height.

Mosaicking of the ADS100 pushbroom image data is reduced in comparison to frame imagery due to the continuous swath of data collected: seamlines are primarily required only on the edges of the image swath. The following graphic shows seamlines from the ADS100 compared to the seamlines required for a frame camera (DMC-1) covering the same project area (St. Louis, 2012, 6-inch GSD). The linear miles of ADS seamlines is 1/20th that of the DMC-1 for this project.

Tile Writing

During this step, all balancing adjustments and seamlines are applied to the individual orthoimages to create the Master Tiles. Once this is complete, all deliverable tiles can be generated. Using our custom software, virtually any tile layout can be generated on demand using automated batch processing. This includes support for:

- Overlapping and contiguous tile layouts.
- Multiple tile layouts.
- Creating tiles in other map projections and/or linear units (e.g.: meter, US Survey Foot).
- Downsampling the resolution, such as creating a 1' resolution tile set from a 6" tile set.
- Since the Master Tiles are in 4x12 format, tiles can be delivered as such or remapped to 8 bits/pixel, and in color or color infrared (CIR).
- Supported output formats include MrSID, GeoTIFF, JPEG, JPEG200, ECW, TIFF/TFW, etc.

Besides the obvious ability to generate data in virtually any desired tile layout, the Master Tile concept makes error correction during inspection very simple. Once an error is corrected in the Master Tiles, all applicable client tile layouts are automatically re-generated, limiting the correction to a single action potentially resolving numerous deliverable tiles.

ACCURACY ASSESSMENT

Surdex has extensive experience meeting ASPRS Class I and the new ASPRS "Standard Mapping and GIS Work" class. The following table summarizes some recent experience with resolutions of 1'/30cm and 6"/15cm projects. ASPRS figures are based on calculations for the required 25cm GSD consistent with ASPRS procedures. As can be seen, we have performed well within the ASPRS standards.

Sample Achieved Accuracies on Recent Projects				
Project	GSD	ASPRS CE95	Measured CE95	Comments
ASPRS Standard Mapping and GIS Work	0.82' (25cm)	4.02' (122.4cm)		"Standard Mapping and GIS Work" class recently replaced the previous "Class I" designation
H-GAC 2015	1' (30.5cm)	4.90' (149.2cm)	1.53' (46.6cm)	Houston-Galveston Area Council
NC 2015	6" (15.25cm)	2.45' (74.7cm)	0.94' (28.7cm)	State of North Carolina

Surdex uses the Accuracy Analyst software from CompassData for assessment of digital orthoimagery accuracy. This software accepts control point coordinates and guides the user through measuring points on each tile. It has extensive analysis and reporting tools that adhere to NSSDA specifications and guidelines.

QUALITY CONTROL SYSTEMS

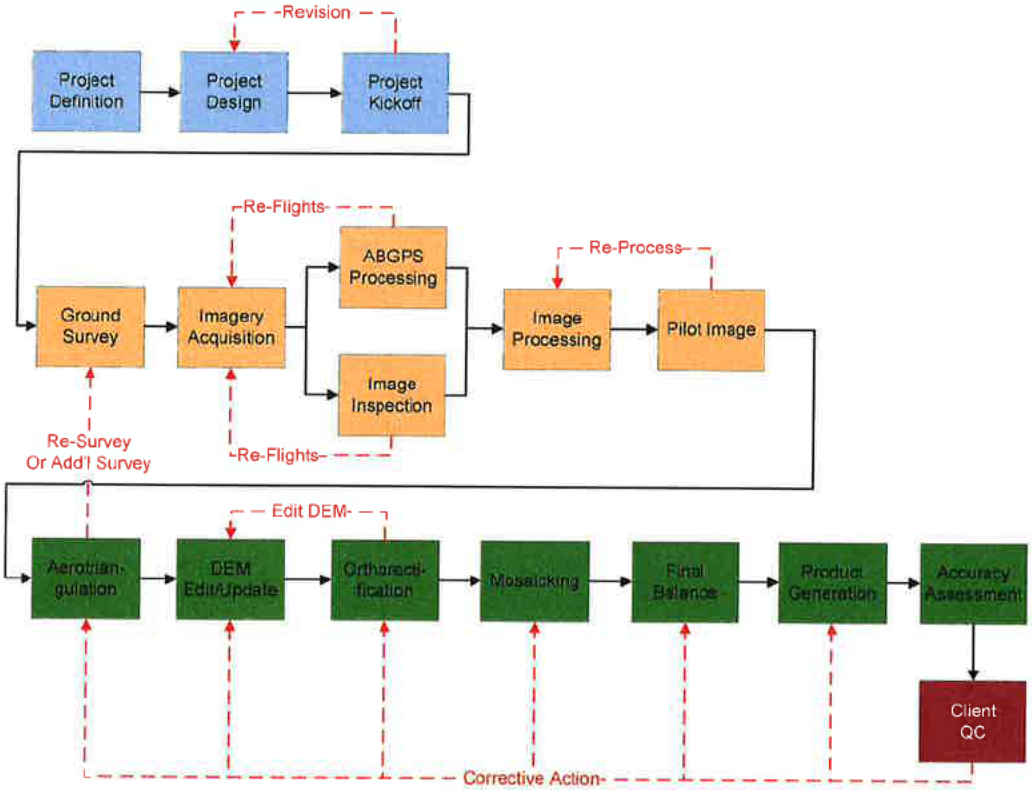
Building upon achieving ISO Certification for specific geospatial products for the National Geospatial-Intelligence Agency, Surdex has embarked on a goal of achieving company-wide ISO Certification by December, 2017. Much work on documentation, such as work instructions, is well underway.

Surdex's personnel have extensive experience and credentials that apply to the QA/QC mechanism:

- Most of our Project Managers (PM) are Certified Photogrammetrists (CP).
- The Director of Project Management, Mr. Tim Bohn, is certified by the Project Management Institute (PMI).
- Our Team includes numerous Registered Land Surveyors (RLS).
- Aerotriangulation personnel and/or reviewers include numerous Certified Photogrammetrists.

Our QA/QC mechanism addresses the processes involved in the production of digital orthoimagery. The following figure highlights the key steps in the process. Red flow lines illustrate loop-backs in the process due to rejection/failure of a step.

Overview of Surdex's QA / QC Process.



EARLY ACCESS ORTHOIMAGERY

With several years of web services hosting experience behind us on the USDA National Agriculture Imagery Program (NAIP) and over five years of experience with our web-based inspection tool, Surdex is in the unique position of offering an interim access web service that (1) visually depicts acquisition progress and (2) allows clients to assess whether ground and atmospheric conditions for acquisition were appropriate. This visual depiction is superior to textual reports and graphics of progress for many users. For large projects requiring acquisition over long periods of time, this provides an important visual status. For smaller projects acquired over shorter periods of time, it represents a first look at the imagery before full-up production is begun.

This service is essentially the same approach as the image service underlying our web-based inspection tool, SurCheck, and will persist until all production imagery is finalized. This can be implemented as a username/password solution to control access or implemented as fully open access. The interim imagery can also be incrementally updated with the final imagery as production progresses, maturing into the final imagery service at the completion of the project and serving as the underpinning of our web-based inspection tool, SurCheck.

Since this is an imagery service, it can be accessed easily as a Java application without a geospatial context, used in any common GIS package, and even accessed by smart phones, tablets, etc.

Orthoimagery is automatically processed to default imagery metrics, suitable for assessing ground conditions, cloud/cloud shadow cover, flooding, snow/ice, fog, smoke, etc. If re-flights are conducted, their result will overwrite any previous imagery, resulting in a view of the most current situation. Surdex has demonstrated posting interim imagery within 5-10 business days of the date of acquisition.

Interim Processing Compared to Final Product Processing			
Item		Interim	Final Product
Aerotriangulation		None performed. Based solely on ABGPS/IMU processing.	Aerotriangulation supported by ABGPS/IMU, ground control.
Orthorectification		To either existing (unedited) elevation surface or USGS NED.	To final (edited) elevation surface.
Accuracy		Generally 2-4X less accurate than final product.	To product specifications
Image Processing		BRDF and atmospheric corrections applied. Default processing to basic image metrics/appearance.	Additional processing to desired final product appearance.
Mosaicking	Seamlines	Automated only.	Automated with manual editing to final product specifications.
	Balancing	Block balance only.	Block and global balance to final product specifications.

The interim imagery web service is an OGC-compliant WMS implementation:

- 4-band imagery viewable as natural color or color infrared (CIR).
- A vector overlay portrays the image bounds complete with acquisition time/date, aircraft tail number, camera make/model/serial number, etc.

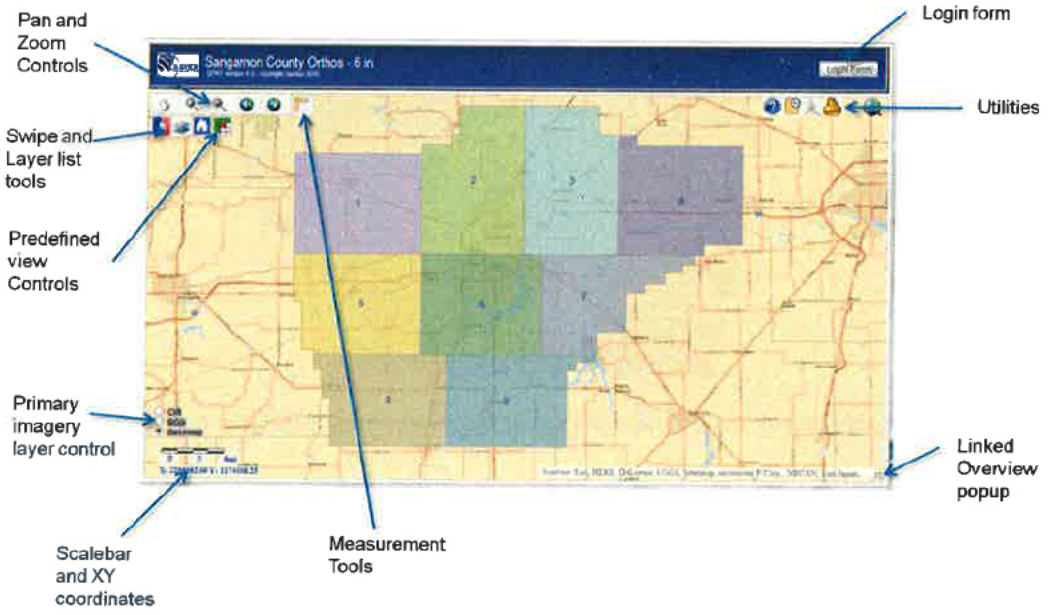
SurCheck[SM] – Surdex's Web-Based Inspection Tool

To assist our clients with the inspection of their orthoimagery, Surdex provides clients with – free of charge – our web-based image inspection tool, SurCheck[SM]. This tool is the result of over five years of continuous improvement and has met with outstanding reviews. It is implemented the HTML5, JavaScript, php, and the ArcGIS API for JavaScript, providing flexibility for enhancements in the future.

SurCheck greatly streamlines the inspection, remedial action, and delivery timelines. As call-outs are reported by reviewers, Surdex resolves each and notifies reviewers so they may confirm the correction. Since Surdex works off call-outs in parallel with the inspection process, in most cases the reviewers receive corrections within 1-2 weeks. When all call-outs are resolved for the project, or a delivery area, the data can be shipped on hard drives for final delivery. In many cases, clients choose to have orthoimagery added to SurCheck incrementally, further expediting inspection and allowing leveling of inspection resources.

Feature	Benefit
Administrative	
Username and password login access.	Protected access for client and reviewers.
Client manager can assign reviewers to separate work zones within a project.	Multiple reviewers for each project to increase inspection rate and support multiple partners. Clients can assign multiple reviewers to specific work zones. Managers can view call-outs from reviewers to ensure a consistent approach.
Four (4) tiers of edit calls: 1. Standard inspector 2. Client manager 3. Surdex reviewer 4. Final client reviewer	Management of call-out resolution with appropriate levels of responsibility and authority within the client and within Surdex. Covers entire life cycle of inspection and resolution process, ensuring end product is fully inspected and accepted. Client manager can override client reviewers. Surdex reviewer dealing with disposition of a call-out (natural feature, out of scope, etc.).
Help menu for most options.	On-line assistance with operation reduces need for a manual or access to training guide, allowing session to continue uninterrupted.
General Interface	
Operates in Internet Explorer, Firefox, Chrome, Edge, and Safari. Works on smart tablets within individual interface limitations.	No browser plug-in required (prior versions required Silverlight). More flexibility for future enhancements requested by users or implemented by Surdex.
Single-page interface with no pop-up windows. Full-screen primary map window. Logical groupings of toolbars.	Simpler and cleaner interface. Maximizes screen real estate for viewing of larger areas. On-demand overview window.
Project start-up view showing basemap and work zones	Overview of assigned areas to ensure familiarization.
Surdex-provided overlay of seamlines	Assists in searches for potential artifacts. Issues along seams or poor placement of seamlines are the most common problem found during inspection.
Ability for users to add their own map services.	Examples include historical imagery, vector overlays, control point overlays, parcels, ArcGIS Online layers, etc.
Swipe function with user-selectable layer.	Combined with user-added image services, provides a quick compare to historical imagery. Can swipe color and CIR renditions of 4-band products to review consistency and quality.

SurCheck layout and tools.



Pan and Zoom Controls

Pan zoom in zoom Out Prev Extent Next Extent

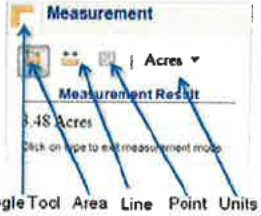
Utilities

Help custom histogram Print Export Magnifier

Predefined view Controls

Project Overview Progress View Active Workzone Active Tile

Measurement Tools

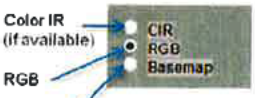


Toogle Tool Area Line Point Units

Inspection Tools

Start/Stop PI Mode
Start/stop Edit Calls
Prev Tile Next Tile

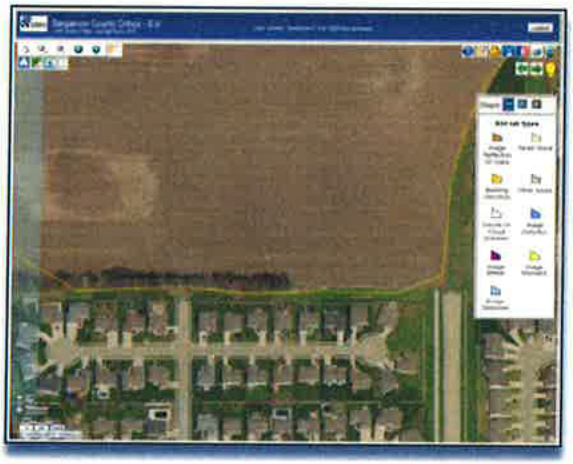
Primary imagery layer control



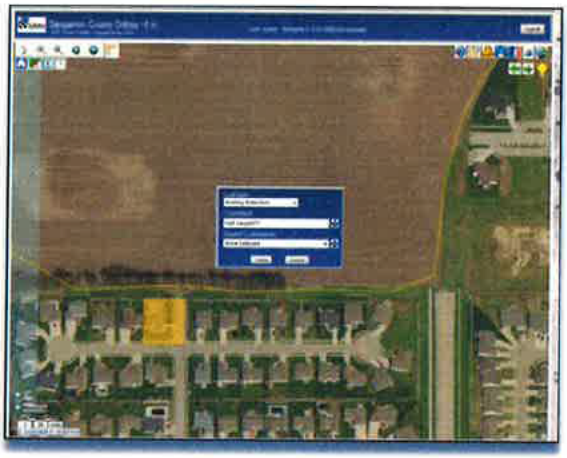
Initial Screen Showing AOIs.

Custom Settings Form.

Edit Calls Template.



Edit Comments.



Swipe Between Color and CIR.

Swipe Between Color and ArcGIS.com

B. Land Use/Land Cover (LULC) and Impervious Surface

The following is a summary of the Land Use/Land Cover (LULC) requirements and specifications.

Land Use / Land Cover (LULC) Requirements and Specifications		
Criteria	Minimum Specifications	Upcharge
Geometry	Polygon based	
Deliverable Data Format	Esri geodatabase	
Classification Scheme	Modified Anderson – as with 2012 project	
Minimum Mapping Unit	1/4 acre wetlands, 2 acre	
Coordinate System	DE State Plane (meters)	
Datums	NAD83, NAVD88	
Metadata	Project level	Feature level
Impervious Surface	Raster deliverable	Finer resolution in urban areas
Base aerial imagery	Most recent collected	
Base LULC	Update of most recent LULC	
Collection frequency	4 years	

The Surdex team will interpret 2017 ortho-imagery to update the 2012 land use and/cover (LULC) dataset for the State of Delaware. In addition, we will reference the 2012 orthoimagery as well as the public domain NAIP imagery from 2015, which provides a leaf-on aspect to aid interpretation. The ortho-imagery will be classified and delineated into polygons (vector-based data) using the Anderson LULC scheme (Anderson 1976). In addition, the project team will develop raster data of impervious surfaces as a schema in the land use/land cover classification.

Due to the availability of the 2012 LULC data and orthoimagery to assist us, our Team feels that a field survey validation of the 2017 LULC data is not required. However, we are offering an optional price for the field survey validation for the State to consider.

Wetlands/Uplands Classification

The high-resolution, 4-band, remote sensing imagery will be initially classified using a supervised classification method to accurately delineate wetlands and upland areas based on the modified version of the Anderson classification for land use/land cover scheme, including refined forested wetlands data classifications that the State added in the 2012 LULC dataset.

- Uplands are referred to as Level I Anderson classes for Agricultural Land, Rangeland, Forest Land, and Barren Land.
- The refined forested wetlands data classes are Tidal Forested Wetland, Tidal Scrub/Shrub Wetland, Tidal Emergent Wetland, Non-tidal Forested Wetland, Non-tidal Scrub/Shrub Wetland, and Non-tidal Emergent Wetland.

In addition, a detailed raster surface of Impervious Surfaces, derived from the orthoimagery, will be created. The new Impervious Surfaces raster will be used as a guide for interpretation of land use/land cover, and the 2012 land use/land cover dataset from the State will provide a baseline classification scheme for comparison to new data. The minimum mapping unit (.25-acre wetlands and 2-acre uplands) will also allow for comparison to the 2012 dataset to determine changes in land classification during the past few years.

Post-Processing

Prior to specific sampling design, statistics will be calculated to ensure the number of field sites is sufficient for each habitat type. Field personnel will identify the land cover classification of each location independently and from different viewing angles, and the final decision on land cover type will be made on a majority basis.

Field Verification

Field data will be collected to validate the wetlands/uplands classification and delineation. A stratified random sampling approach will be used to collect these field data. Field sample locations will be determined with reference of historical classification maps and other readily available ancillary data, such as boundaries of public accessible facilities (i.e., roads and parks). The proposed sampling approach will ensure the following:

- The number of reference points for each land use class is adequate to achieve the accuracy goals.
- Sample locations are publically accessible.
- Samples can be collected efficiently.

Accuracy Assessment

Photointerpretation will be conducted in ArcGIS by randomly distributing an appropriate number of stratified reference points. The number, stratification, and distribution of the points will be adjusted as needed to ensure complete, adequate coverage of all potential wetlands/upland classes and redundancy between photointerpretation.

The primary quality assurance (QA) goal for wetlands/upland classification accuracy is dictated by the minimum mapping unit of .25 acre for wetlands and 2 acres for uplands as the target mapping unit (TMU). The goal of this project is to ensure the LULC mapping update meets this state standard of a 98% producer's accuracy goal for wetlands and upland features. Evaluation of this accuracy goal will be conducted by in-office review of data by remote sensing experts and ecologists.

Trend Analysis

Following the finalization of wetlands/upland classification polygons, a trend analysis will be conducted using spatial analysis tools within ArcGIS and Python scripts to quantify changes and reveal potential trends in LULC from 2012 to the current dataset. A comparison with the previous LULC classification will be made, and areas of change will be identified and documented in a polygon feature class. Planning level GIS data, such as zoning, assessor parcels, UGA, and conservation areas, will be used together with the change-identified polygon feature class to further quantify and summarize the changes. Potential change patterns will also be forecast on the basis of the identified changes from 2012 to 2016 and other analyses such as spatial clustering and geomorphology. A map set will be developed to illustrate identified changes and trends.

Various error matrices (i.e., user accuracy, producer accuracy, overall accuracy, and Kappa) will be calculated to fully assess the classification results (Congalton 1991).

Wetlands/Upland Classification Accuracy

The primary QA goal for LULC classification accuracy is dictated by the federal wetlands mapping standard (FGDC 2009). In addition to this goal, and optionally-priced field validation will be conducted to determine the percentage of field-observed LULC classes that are correctly identified. The field validation effort will rely on approximately 1,350 carefully selected (stratified random) points for the production mapping phase that will be visited to make a field LULC determination and classification. The sampling design will aim to collect field observations from each of the Anderson classes, including the refined forested wetlands found in the data from the 2017 orthorectified aerial photography.

REFERENCES

- Anderson, J., E.E. Hardy, J.T. Roach, and R.E. Witmer, 1976. *A Land Use and Land Cover Classification System for Use with Remote Sensor Data*. Geological Survey Professional Paper 964. U.S. Government Printing Office, Washington, D.C.
- Congalton, R., 1991. A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data. *Remote Sensing Environment* 37(1): 35-46.
- FGDC (Federal Geographic Data Committee, Wetlands Subcommittee), 2009. *Wetlands Mapping Standard*. FGDC Document Number FGDC-STD-015-2009. July 2009.

C. SCHEDULE

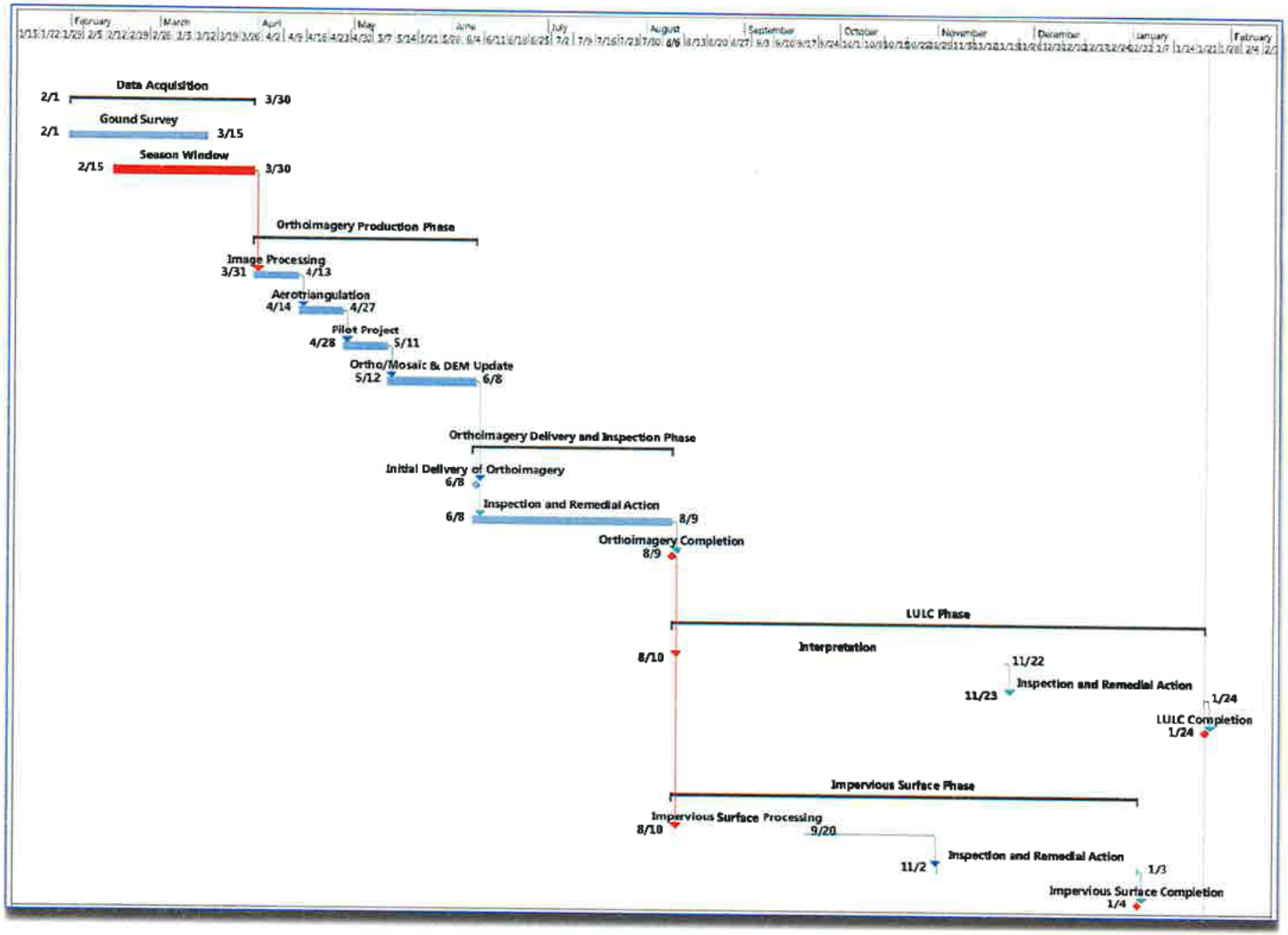
In this section, Surdex presents a preliminary schedule based on information from the RFP:

- Acquisition and processing of 25cm imagery.
- Acquisition in the winter/spring months of 2017.
- The desire of the State to have delivery of the orthoimagery by fall 2017.
- Delivery of the LULC within 6-12 months after delivery of the orthoimagery.

The preliminary schedule is based on the following additional assumptions by Surdex:

- Based on knowledge of the area, we expect this will be in the range of mid February through late March. For initial planning purposes, we are assuming completion of aerial acquisition at the end of March, presenting somewhat of a pessimistic scenario.
  - It is reasonable to assume that if acquisition completes earlier than the assumed date, that all production and deliverable schedules will be moved up accordingly.
  - It is also reasonable to assume that a later completion of acquisition will move production and deliverable schedules back accordingly.
- Ground survey operations will commence prior to, and complete by the end of aerial acquisition.

Preliminary Schedule



ATTACHMENT 2

CONTRACT NO.: **OMB-016-GISDATA**
CONTRACT TITLE: **AERIAL IMAGERY AND LAND USE/LAND COVER GIS DATA DEADLINE TO RESPOND:** **August 26, 2016 at 4:00 PM (Local Time)**

NON-COLLUSION STATEMENT

This is to certify that the undersigned Vendor has neither directly nor indirectly, entered into any agreement, participated in any collusion or otherwise taken any action in restraint of free competitive bidding in connection with this proposal, **and further certifies that it is not a sub-contractor to another Vendor who also submitted a proposal as a primary Vendor in response to this solicitation** submitted this date to the State of Delaware, Office of State Planning Coordination.

It is agreed by the undersigned Vendor that the signed delivery of this bid represents, subject to any express exceptions set forth at Attachment 3, the Vendor's acceptance of the terms and conditions of this solicitation including all specifications and special provisions.

NOTE: Signature of the authorized representative **MUST** be of an individual who legally may enter his/her organization into a formal contract with the State of Delaware, Office of State Planning Coordination.

COMPANY NAME Surdex Corporation (Check one)

✓	Corporation
	Partnership
	Individual

NAME OF AUTHORIZED REPRESENTATIVE
(Please type or print) Ronald C. Hoffmann

SIGNATURE RC Hoffmann TITLE President

COMPANY ADDRESS 520 Spirit of St. Louis Blvd., Chesterfield, MO 63005

PHONE NUMBER 636-368-4400 FAX NUMBER 636-368-4401

EMAIL ADDRESS RonHCorp@surdex.com

FEDERAL E.I. NUMBER [redacted] STATE OF DELAWARE LICENSE NUMBER Surdex will apply for License

COMPANY CLASSIFICATIONS:	Certification type(s)	Circle all that apply
CERT. NO.: N/A	Minority Business Enterprise (MBE)	Yes (No)
	Woman Business Enterprise (WBE)	Yes (No)
	Disadvantaged Business Enterprise (DBE)	Yes (No)
	Veteran Owned Business Enterprise (VOBE)	Yes (No)
	Service Disabled Veteran Owned Business Enterprise (SDVOBE)	Yes (No)

[The above table is for informational and statistical use only.]

PURCHASE ORDERS SHOULD BE SENT TO:
(COMPANY NAME) Surdex Corporation
ADDRESS 520 Spirit of St. Louis Blvd., Chesterfield, MO 63005
CONTACT Cornell Rowan, Project Manager
PHONE NUMBER Direct 636-368-4460 Main 636-368-4400 FAX NUMBER 636-368-4401
EMAIL ADDRESS CornellR@surdex.com

AFFIRMATION: Within the past five years, has your firm, any affiliate, any predecessor company or entity, owner, Director, officer, partner or proprietor been the subject of a Federal, State, Local government suspension or debarment?
YES ____ NO X ____ if yes, please explain ____

THIS PAGE SHALL HAVE ORIGINAL SIGNATURE, BE NOTARIZED AND BE RETURNED WITH YOUR PROPOSAL

SWORN TO AND SUBSCRIBED BEFORE ME this 24 day of August, 2016
Notary Public Lorie Thomas My commission expires June 13, 2020
City of St. Louis County of St. Louis State of Missouri

LORIE THOMAS
Notary Public - Notary Seal
State of Missouri, St Louis County
Commission Number 99416841
My Commission Expires Jun 13, 2020

ATTACHMENT 4

Contract No. **OMB-016-GISDATA**

Contract Title: **AERIAL IMAGERY AND LAND USE/LAND COVER GIS DATA**

CONFIDENTIAL INFORMATION FORM

☒ By checking this box, the Vendor acknowledges that they are not providing any information they declare to be confidential or proprietary for the purpose of production under 29 Del. C. ch. 100, Delaware Freedom of Information Act.

Confidentiality and Proprietary Information
Surdex's proposal does not include confidential or proprietary info.

Note: Vendor may use additional pages as necessary, but the format shall be the same as provided above.

ATTACHMENT 6

SUBCONTRACTOR INFORMATION FORM

PART I – STATEMENT BY PROPOSING VENDOR

1. CONTRACT NO.	2. Proposing Vendor Name:	3. Mailing Address
OMB-016-GISDATA	Surdex Corporation	520 Spirit of St. Louis Blvd. Chesterfield, MO 63005

4. SUBCONTRACTOR

a. NAME	4c. Company OSD Classification: Certification Number: None
Anchor QEA, LLC	

b. Mailing Address:			
614 Magnolia Avenue Ocean Springs, MS 39564	4d. Women Business Enterprise	Yes	(No)
	4e. Minority Business Enterprise	Yes	(No)
	4f. Disadvantaged Business Enterprise	Yes	(No)
	4g. Veteran Owned Business Enterprise	Yes	(No)
	4h. Service Disabled Veteran Owned Business Enterprise	Yes	(No)

5. DESCRIPTION OF WORK BY SUBCONTRACTOR

- Lead role to develop the land use/land cover data for this project.
- Support Surdex with the creation of impervious surface data for the completion of this project.

6a. NAME OF PERSON SIGNING	7. BY (*Signature*)	8. DATE SIGNED
Ronald C. Hoffmann	R. C. Hoffmann	8/23/2016
6b. TITLE OF PERSON SIGNING President		

PART II – ACKNOWLEDGEMENT BY SUBCONTRACTOR

9a. NAME OF PERSON SIGNING	10. BY (*Signature*)	11. DATE SIGNED
9b. TITLE OF PERSON SIGNING		*8/23/2016*

** Use a separate form for each subcontractor*

STATE OF DELAWARE
OFFICE OF MANAGEMENT AND BUDGET

PERFORMANCE BOND

Bond Number: _____

KNOW ALL PERSONS BY THESE PRESENTS, that we, _____, as principal ("**Principal**"), and _____, a _____ corporation, legally authorized to do business in the State of Delaware, as surety ("**Surety**"), are held and firmly bound unto the _____ ("**Owner**") (***insert State agency name***), in the amount of _____ ($_____), to be paid to **Owner**, for which payment well and truly to be made, we do bind ourselves, our and each and every of our heirs, executors, administrations, successors and assigns, jointly and severally, for and in the whole, firmly by these presents.

Sealed with our seals and dated this _____ day of _____, 20__.

NOW THE CONDITION OF THIS OBLIGATION IS SUCH, that if **Principal**, who has been awarded by **Owner** that certain contract known as Contract No. _____ dated the _____ day of _____, 20__ (the "Contract"), which Contract is incorporated herein by reference, shall well and truly provide and furnish all materials, appliances and tools and perform all the work required under and pursuant to the terms and conditions of the Contract and the Contract Documents (as defined in the Contract) or any changes or modifications thereto made as therein provided, shall make good and reimburse **Owner** sufficient funds to pay the costs of completing the Contract that **Owner** may sustain by reason of any failure or default on the part of **Principal**, and shall also indemnify and save harmless **Owner** from all costs, damages and expenses arising out of or by reason of the performance of the Contract and for as long as provided by the Contract; then this obligation shall be void, otherwise to be and remain in full force and effect.

Surety, for value received, hereby stipulates and agrees, if requested to do so by **Owner**, to fully perform and complete the work to be performed under the Contract pursuant to the terms, conditions and covenants thereof, if for any cause **Principal** fails or neglects to so fully perform and complete such work.

Surety, for value received, for itself and its successors and assigns, hereby stipulates and agrees that the obligation of **Surety** and its bond shall be in no way impaired or affected by any extension of time, modification, omission, addition or change in or to the Contract or the work to be performed thereunder, or by any payment thereunder before the time required therein, or by any waiver of any provisions thereof, or by any assignment, subletting or other transfer thereof or of any work to be performed or any monies due or to become due thereunder; and **Surety** hereby waives notice of any and all such extensions, modifications, omissions, additions, changes, payments, waivers, assignments, subcontracts and transfers and hereby expressly stipulates and agrees that any and all things done and omitted to be done by and in relation to assignees, subcontractors, and other