sanborn

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Due: 2:00 p.m.

Wednesday, December 17, 2014

Prepared exclusively for:

Central Oklahoma Alliance of Government Agencies 2015

Regional Digital Orthophoto Images and Associated Data RFP #2015-01

Copy

sanborn

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December 16, 2014

Mr. John Sharp
ACOG
21 E Main St Suite 100
Oklahoma City, OK 73104-2405

Re: Regional Digital Orthophoto Images and Associated Data RFP #2015-01

Dear Mr. Sharp:

As professionals and longtime providers of geospatial products and services to government agencies, The Sanborn Map Company, Inc. (Sanborn), appreciates the challenges that the Central Oklahoma Alliance of Government Agencies 2015 (COAGA 2015) face in managing your resources and environment. Sanborn understands that COAGA 2015 has made a significant investment in GIS, and supports a variety of applications to enhance the level of service provided by various departments. The foundation of all of these applications is accurate, up-to-date base map data, including digital orthophotography, terrain surface, and planimetric base layers.

We understand the mission-critical nature of this project, and the need to ensure that you receive quality orthoimagery, hydro-flattened LiDAR and updates of your planimetric data on time, on budget, and to your specifications.

Sanborn is a 21st century industry leader in geospatial solutions and technology. Established in 1866, we are headquartered in Colorado Springs, CO, with satellite production offices in Charlotte, NC, and Pelham, NY. Sanborn's primary business function is providing professional mapping and GIS services to public and private sector organizations around the world.

On behalf of Sanborn, it is my pleasure to submit this proposal to you for the project referenced above. Sanborn, an ISO 9001:2008-certified company, is excited about the opportunity to work with COAGA 2015 on the project referenced above and we satisfy all requirements of your RFP, as well as provide several differentiators outlined in our proposal. The Sanborn team possesses the qualified staffing, state-of-the-art equipment, relevant experience, and strong resolve to provide this level of service on a consistent basis.

We look forward to the opportunity to discuss our technical approach in more detail and to personally introduce to you the key members of our team. Our proposal has addressed the entire Request for Proposals requirements; however, should you have questions or need clarification, please contact Ms. Krysia Sapeta, Director of Strategic Accounts, at (321) 298-1744 or ksapeta@sanborn.com. We appreciate the opportunity to submit a proposal to you, and we look forward to the results of your evaluation.

Sanborn acknowledges receipt of the email dated December 5, 2014, containing boundary files, the email dated December 8, 2014, containing the non-collusion affidavit form, and the email dated December 9, 2014, extending the due date.

Sincerely,

Susan Passon-Alexander
for John R. Copple
President/CEO

Enclosures

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Section 1 – Project Overview

Company Overview

The Sanborn Map Company, Inc. (Sanborn) is a full-service geospatial company that has been in continuous operation since 1866. Sanborn offers comprehensive geographic information solutions to city, county, regional, state, and federal government agencies, private companies, and international clients. Our services include:

- GPS ground control surveys
- Aerial imagery acquisition, including airborne GPS and IMU controlled imagery, using advanced digital aerial imagery sensors
- Digital orthophoto imagery creation
- Digital oblique imagery creation
- Airborne, terrestrial and mobile LiDAR data acquisition and production for digital elevation/terrain and feature modeling
- Planimetric and topographic mapping
- Remote sensing analysis, including change detection, land cover/land use mapping, impervious/pervious surface mapping, and fire risk assessments
- Data collection, and utility and asset inventory creation
- 3D infrastructure modeling and simulation
- Parcel, facility and data conversion mapping
- GIS and CAD database creation
- GeoIT support including data analysis, data hosting, website creation, and custom application development

Sanborn is headquartered in Colorado Springs, Colorado. With three technology centers across the United States, Sanborn offers local presence, extensive resources, and quick response times.

Our team of over 125 mapping and GIS professionals has decades of experience in all facets of the industry, proven project management skills, and expertise in many database systems and GIS platforms. As an ISO 9001:2008-certified company, Sanborn is dedicated to excellence and to fulfilling our clients' needs in an efficient, accurate, and timely fashion.

The Sanborn Map Company, Inc.	
Address	1935 Jamboree Dr., Suite 100 Colorado Springs, CO 80920
Telephone/Fax	(719) 593-0093 / (719) 528-5093
Internet Address	www.sanborn.com
Year Established	1866
Office to Provide Services	Colorado Springs, Colorado (Corporate Office)
Other Offices	▪ Pelham, NY ▪ Charlotte, NC
Type of Ownership	The Sanborn Map Company, Inc. is a privately owned company incorporated in the State of Delaware, U.S.A.
Registration	Sanborn is licensed to do business in the State of Oklahoma, under ID number 2312026563

History

Sanborn is a successful, well-established mapping company in the United States. In 1866, our focus was the creation and maintenance of fire insurance maps used primarily for fire insurance underwriting. Sanborn has never lost focus of our original function as a map-maker; and today, Sanborn utilizes the latest equipment and technology, while continually developing improved processes, to produce and deliver quality geospatial solutions for our contemporary clients:

- In 1960, Sanborn expanded into new markets with a variety of new thematic map styles such as market radius, noise abatement, and land use maps. Sanborn also continued to develop services using computers for tax parcel mapping and land/building usage databases.
- Sanborn began offering aerial photography and mapping services in 1966 as the result of a merger with an aerial mapping firm.
- In 1984, Sanborn became one of the first companies to use digital terrain modeling and contour interpolation techniques to produce topographic data.
- In 1988, Sanborn was the first company to develop and implement a commercially viable system for the production of digital orthophoto imagery.
- Sanborn continued to expand its services by purchasing its first LiDAR system in 1998; and, invested in its first terrestrial LiDAR scanning instrument in 2003, to complement the aerial LiDAR business line
- In 2004, Sanborn acquired its first digital aerial cameras, and has continually invested in the most useful and effective equipment
- Sanborn acquired its first digital oblique aerial imagery sensor in 2011, and now owns 3 of these systems.
- In 2013, Sanborn acquired three new Vexcel UltraCam Eagle cameras, and implemented them into the aerial photo production business line.

Since acquisition of our first LiDAR and digital aerial systems, Sanborn has collected data for and mapped hundreds of thousands of square miles of terrain; and, is one of the most advanced LiDAR and digital imaging firms today.

Sanborn owns and operates one aerial LiDAR instrument, two terrestrial LiDAR instruments, and nine digital sensors for imaging; and, operates a fleet of aircraft consisting of four turbine aircraft, five twin engine piston aircraft, and three single engine aircraft.

Sanborn continues to set industry standards in excellence. The Sanborn name is synonymous with high quality mapping and GIS services. Our team of mapping and GIS professionals has decades of experience in all facets of the industry, proven project management skills, and expertise with many data collection and processing technologies, database systems and GIS platforms. In all aspects, Sanborn provides innovative solutions and quality service to our customers.

Experience and Sanborn Team

Sanborn has always recognized the importance of playing an industry-leading role and providing clients with access to the most progressive solutions available, enabling us to deliver products and services in the most timely and cost-effective manner possible. The company has had a number of important "firsts" in aerial mapping and imaging, including pioneering the use of digital terrain modeling techniques and contour interpolation in 1984, and having the first commercial, proprietary, digital orthophoto imagery production system in the country in 1988. Sanborn purchased its first LiDAR system in 1998, and began operating digital aerial camera sensors in 2004.

Relevant Experience

Sanborn has a demonstrable track record of success on large, complex orthoimagery, LiDAR, and photogrammetric mapping projects throughout the United States. The company has extensive experience throughout the US and we have mapped hundreds of square miles of terrain throughout the United States.

Sanborn's aircrews are experiences and familiar with the airspace system in the Midwest and Southern US, and know how to navigate safely and efficiently within its boundaries. They have the relationships needed to gain access to the sensitive and restricted areas. They know the terrain and local weather patterns, and how to structure mobilizations to take maximum advantage of the limited time window in which to collect leaf-off imagery.

Sanborn has recently completed large orthoimagery creation, LiDAR and photogrammetric mapping projects for the States of Michigan, Louisiana, Wyoming, and Kansas. Additionally, Sanborn has performed airborne imagery acquisition and creation of digital orthophotography of the States of South Dakota, Arizona, New Mexico, Colorado, and Tennessee under contract to the U.S. Department of Agriculture for their NAIP and NAPP programs. Sanborn's recent project involvement has included statewide imagery programs that required collection of imagery for areas exceeding 40,000 square miles, and delivering tens of thousands of orthoimagery tiles within the space of 6-8 months. Over the last five years, Sanborn has worked hard to improve our acceptance rates for our imagery and LiDAR products and is currently at a 98% first time acceptance rate.

Sanborn has successfully worked with numerous other consortiums to perform similar projects. Our clients include the State of Virginia's Base Mapping Program, Greater Bridgeport Regional Council, Windham Region Council of Governments, Louisville/Jefferson County Information Consortium, Pikes Peak Geospatial Alliance, and the Houston-Galveston Area Council (HGAC). In addition to coordinating and communicating as needed to complete their imagery, LiDAR and mapping projects, Sanborn has hosted informational seminars, developed and delivered in coordination with the governing body, that are held prior to the main flying seasons (and off-seasons as appropriate), to aid in educating and supporting the wide-ranging needs of their constituents.

Key Personnel

Sanborn's experience with and ability to manage large, complex LiDAR, orthoimagery and photogrammetric mapping projects is due in no small part to significant investments in human and equipment resources. The Sanborn team of over 125 geospatial technology and management professionals possesses an enviable resume of project experience, significant educational credentials, and registration from government agencies and leading industry associations.

Sanborn's Project Manager for COAGA 2015's project will be Mr. Kris Andersen. Mr. Andersen has over 15 years of experience managing Geospatial programs, including statewide collections for Michigan and Louisiana as well as large programs for Maricopa County, AZ; the Southern Nevada Water Authority; Pima Association of Governments, AZ; and the Southern California Council of Governments. He will be COAGA 2015's single point of contact and will serve as COAGA 2015's liaison with Sanborn operations staff and management.

Sanborn offers COAGA 2015 an exceptionally qualified project team with many years of experience in digital orthoimagery and photogrammetric mapping. Mr. Andersen is supported by multiple Certified Photogrammetrists (CP), Professional Land Surveyors (PLS), GIS Professionals (GISP), and Certified Mapping Specialists (CMS).

Subcontractor Overview

To increase Sanborn's capacity and resource base, Sanborn has also provided ***optional*** pricing using an offshore subcontractor, Shandong Eastdawn Corporation, for additional production support.

Eastdawn

Shandong Eastdawn Corporation (Eastdawn) is a leading international geospatial service provider with established clients in Asia, Europe, South America, Africa and North America. As a Class-A surveying and mapping company certified by the National Administration of Surveying, Mapping and Geoinformation, the company serves its customers across a wide range of geospatial services including GIS, LiDAR and photogrammetry from space, airborne and terrestrial data sources. Based in Jinan, Shandong Province, Eastdawn has sales offices in China, Japan, Europe and the USA. The company is highly customer focused, providing superior levels of service for its clients.

Eastdawn is a subsidiary of Beijing Eastdawn Information Technology Co. Ltd., headquartered in Beijing China. Eastdawn is a global geospatial data production and remote sensing company established in November 2001. The company is one of the largest privately owned geospatial data production companies in China and is the exclusive provider of six international satellite data sources in the region. The company currently employs more than 800 employees.

Subcontractor Management

For any project that utilizes subcontracted services and products, it is essential to have an experienced subcontract manager, subcontractor SOW, and a subcontract management plan. Sanborn's ISO processes make certain these documents and personnel are in place is to ensure purchase orders are properly executed, providing the appropriate controls to meet the program schedule, budgets, and technically compliant services and products, and to review the progress of the subcontractor and subcontract management activities.

Project Approach

Sanborn has the capability and capacity to perform all services identified in the RFP.

Sanborn owns the required aircraft, and aerial sensors required for the critical acquisition phase of the program, which is the foundation for quality data and provides the ability to maintain schedule. We are committed to the acquisition of digital aerial imagery during the spring of 2015 under ideal conditions for imagery capture in the project area, as well as acquisition of LiDAR during the same timeframe.

Sanborn possesses experienced and certified staff, state-of-the-art equipment, relevant similar project experience, and strong resolve to meet or exceed your requirements and accuracy specifications. Our goal is to provide COAGA 2015 members high quality, accurate, crisp, interpretable, as well as aesthetically pleasing orthoimagery. If selected by the participants, newly acquired high accurate LiDAR will be hydro-flattened and quality derivative products generated included the interpolation of contours. We have also provided the option for a 100% comprehensive update of planimetric features.

Scope of Work

Sanborn understands that COAGA 2015 wishes to procure:

- New color aerial imagery;
- Establishment or recovery of ground control as needed to support the project managed by a certified Oklahoma PLS
- Aerial triangulation services as needed to position, orient, and tie the newly-acquired aerial imagery, and verify the integrity of the control solution;
- An updated digital elevation model (DEM) that will support accurate orthorectification;
- All members require new 6-inch or 3-inch spatial resolution, 3-band, 8-bit-per-channel, RGB true natural color digital orthophotography. ** Please note that Sanborn offers delivery of the 4th band (NIR) as an optional product, at no additional costs. Individual members may choose to have their product delivery at either 3-band or 4-band delivery.
- The new orthoimagery will meet or exceed ASPRS Class 1 specifications and the DEM will be updated as necessary to properly rectify the entire project area, including areas of change. The new imagery acquired and supported with additional ground control will provide enhanced accuracy.
- Delivery of orthoimagery in Uncompressed GeoTiff PLSS tile format and associated TIFF World header files, for the relevant resolutions
- MrSid and JP2000 compressed files of the entire project Area

- Supplemental documentation, reports, and deliverables created as a part of the production process for all data layers, as outlined in the RFP, including FGDC compliant metadata.

Optional Products

- Optional MrSID Mosaic and JP2000 products, as defined for each area
- Updated planimetric data layers for Edmond, Choctaw, Moore, Norman; all newly acquired planimetric data will meet or exceed ASPRS Class 1 specification; the existing data will meet the original compiled specification.
- Optional hydro-flattened LiDAR for Edmond (with updated HE-DEM and 1-foot contours), Choctaw (with updated HE-DEM and 2-foot contours, Norman (with updated HE-DEM and 1-foot/2-foot contours) and Moore (with updated HE-DEM and 2' contours). All LiDAR and LiDAR products will meet or exceed ASPRS Class 1 specifications.

Mapping limit AOI's are understood to be as outlined in Appendices C through I of the RFP. The data layers are to be geo-referenced and projected in the

- NAD83 (HARN) Oklahoma State Plane, South Zone 3502 NAVD88 US Survey Feet – Moore and Norman
- NAD 1983 Oklahoma State Plane, North Zone 3501 NAVD88 US Survey Feet – all others

Key Production Tasks

Capacity: Timely, consistent, and quality collection of aerial imagery and LiDAR data is the cornerstone for generating accurate, quality data. Sanborn owns (12) aircraft, (7) Digital Cameras and (1) latest technology Leica ALS70-HP aerial LiDAR systems. This Capacity along with our robust hardware and software equipment sets the stage for adherence to schedule.

Aerial Imagery Acquisition: One of the most critical phases of this project is acquisition of the color 2015 aerial imagery, and is the cornerstone for meeting schedule and generating highly accurate and quality photogrammetric basemap products. Sanborn owns three (3) Microsoft Eagle sensors that our proposed for your program. We have sufficient resources to provide COAGA 2015 the assurance that the acquisition is completed on time and within the environmental parameters, for the critical acquisition phase. Aerial acquisition status is updated **daily**, and will be provided to COAGA 2015 via a password protected website and illustrated with flight line design plans and phases of completion. Imagery will be acquired at 6-inch resolution for Choctaw, Midwest City, Moore, Norman, and Oklahoma County, and at 3-inch resolution for Edmond, Choctaw and Norman. There will be no re-sampling of the data; the initial pixel resolution will be of finer resolution than the final product.

Digital Imagery System*:* Collection of ABGPS/IMU-controlled vertical color imagery for this project will be performed by Sanborn with the advanced UltraCam Eagle digital aerial camera system with 3rd generation architecture. We have used the Eagle on numerous mapping programs requiring similar mapping standards, including the 2013 MS multi-County program. The Eagle acquires multispectral imagery (R, G, B, NIR) and features state-of-the art CCD technology, a lower signal-to-noise ratio and better interpretability in areas where shadows are unavoidably present and the 100mm lens minimizes building displacement/lean.

Ground Control & Aerial Triangulation; Sanborn will utilize existing ground control on this project to the fullest extent possible, and augment it with new, photo-identifiable ground control points where needed. Mr. Steve Wood, Oklahoma PLS # 1166 (since 7/11/80), will perform and certify the survey. Using the ground control survey information, camera calibration information and Airborne GPS/Inertial Measurement Unit (AGPS/IMU) data acquired during the aerial flight, a Fully Analytical Aerial Triangulation (FAAT) solution will be completed, to establish the orthoimagery accuracy.

Accuracy: Sanborn has successfully completed hundreds of mapping programs similar in size and scope to the COAGA 2015 program. We have designed the project to meet or exceed the required ASPRS Class 1 mapping standards. All work with be reviewed, accepted and documented by our Chief Photogrammetrist, Mr. Doug Zehr.

Digital Color Orthophotography: As early as 1988 when Sanborn pioneered Digital Orthophoto production, we have had a department of experienced imaging technicians dedicated solely to the creation of orthoimagery. Our software and workflow will ensure geometrically accurate and radiometrically pleasing imagery, and will facilitate elimination of defects such as image smearing, bridge distortions, radial distortion, seamline /mosaicking errors, and unsightly image artifacts. The DEM source will be either a new LiDAR dataset updated existing DEM. Interim deliverables and pilot/sample data will be provided to COAGA 2015, and COAGA 2015 members will be involved in key decisions regarding subjective aspects of image radiometry. GeoTIFF files, an updated DEM, seamline files and a final project-wide MrSID dataset will be provided.

Metadata and Reports; Sanborn develops FGDC compliant metadata for a majority of our clients and will provide detailed reports/metadata for each deliverable product, as well as supporting documentation and reports.

LiDAR (Option); For specified areas of interest, Sanborn currently owns and operates a state-of-the-art Leica ALS70-HP aerial LiDAR system and proposes to use this system for COAGA 2015's project. Sanborn will acquire and produce hydro-flattened LiDAR derivative products for the entire area, and the data will meet or exceed ASPRS Class 1 accuracy Standards.

Topography (Option): The newly acquired LiDAR data will be used to support the production of new contours for the entire area. This LiDAR data will be sufficiently enhanced with 3-D breaklines to support accurate contour interpolation, and the contours will meet or exceed ASPRS Class 1 specifications for the relative contour interval and scale.

Planimetric Update (Option): For specified areas of interest, experienced Sanborn technicians will perform a comprehensive update of the entire area, by manual technician review. All newly digitized linework will meet exceed ASPRS Class 1 accuracy specifications; existing linework will maintain the original specification it was compiled at.

IT infrastructure; All of COAGA 2015's data will be maintained on Sanborn's robust, state-of-the-art IT infrastructure, capable of processing, storing, and communicating large volumes of data reliably and securely. Sanborn's production IT infrastructure is made up of a powerful 400 node computer processing farm with 1.5 Petabytes of raw storage. In excess of 1600 cores are available when needed for data processing. This infrastructure provides COAGA 2015 the confidence that we have the computing and storage power to effectively process all the products for your program.

Quality Control/Quality Assurance: Data consistency and quality is of critical concern for every project. All Sanborn offices are ISO 9001:2008-certified and adhere to the strict Total Quality Management (TQM) System, ensuring a production workflow that produces exceptional quality. This is accomplished through rigorous quality testing of the interim dataset at all phases of the production process, and closed loop feedback communications with production staff to ensure our staff meet customer expectations and understand COAGA 2015's specifications. Sanborn places an emphasis on problem prevention rather than dependence on detection after occurrence. Sanborn management will exercise tight control over the project, and coordinate our efforts with those of COAGA 2015's management and staff to ensure that this project is completed on time, to specification, and within budget.

Section 2 – Project Approach

Introduction

This section provides a detailed description of the equipment, methods, and procedures Sanborn will use to collect new digital aerial imagery, and produce the required derivative data products and supporting materials in full conformance with the standards and specifications outlined in the RFP. This includes project management, and the steps taken to provide quality assurance and control throughout the entire process.

Project Understanding

Sanborn will perform or provide for all of the necessary tasks, including but not limited to primary data acquisition (ground control surveying, LiDAR and aerial imagery), aerial triangulation, digital elevation modeling, orthorectification, planimetric data update, contour production, quality assurance and control, project management and administration, and generation of full documentation and metadata for the project. All deliverable data products will be in full compliance with the standards and specifications set forth in the RFP.

Pilot Project

Sanborn understands the importance of completing and receiving approval for a pilot project prior to proceeding with full production. We feel this is especially critical in orthoimagery programs, which by their nature call upon us to address aesthetic elements, as well as the quantifiable technical requirements of our customers. Therefore, we will work closely with COAGA 2015 during the project initiation phase to obtain feedback on what your ideal is for the appearance of the imagery in terms of color characteristics, and submit pilot data samples for final approval before completing the remainder of the project in order to ensure that all standards and specifications set for the project will be met. Delivery of the pilot project will take place following completion of aerial data acquisition and digital aerotriangulation.

Digital Aerial Imagery Acquisition

Sanborn recognizes that one of the most critical phases of this project is acquisition of the aerial imagery. Timely collection of consistent, high quality aerial imagery and related data is the foundation for generating high quality digital orthoimagery and other derivative data products.

Our aerial team provides the following benefits to COAGA 2015:

- Extensive, wholly-owned data acquisition resources to ensure collection within optimal windows of opportunity;

- A fleet of twelve aircraft, including high performance multi-engine and turbine-powered aircraft and one craft that is equipped with dual ports, and is capable of performing acquisition with multiple sensors;
- Three (3) three new-generation Microsoft/Vexcel UltraCam Eagles to provide a variety of collection options, including simultaneous RBG and NIR capture;
- AGPS/IMU units to collect photo center position and direct exterior orientation data for imagery; and,
- Aircrews and photographers with extensive experience in the Midwest and Southeast US.

Acquisition Equipment and Resources

A summary of acquisition assets available to COAGA 2015 through our airborne data acquisition team is shown in the table below. Sanborn has sufficient aircraft and sensors to complete airborne data acquisition in Spring 2015, with a very high level of redundancy. Any of the aircraft in the table could be tasked for the COAGA 2015's project, as needed to complete acquisition in a timely manner. The listed aircraft are equipped with gyro-stabilized mounts, computerized flight management systems, and ABGPS/IMU systems for precise photo-center positioning and orientation.

Sanborn Airborne Data Collection Assets	
Aircraft Type and FAA Registration Number	**Sensor Systems**
Multi-engine Piston Piper Navajo PA-31-325; N27693 Multi-engine Piston Piper Navajo PA-31-310; N278RC Multi-engine Piston Aero Commander 500S; N9UB Multi-engine Piston Aero Commander 500B; 6172X Multi-engine Piston Aero Commander 680FL; N4998E Twin-Turbine Aero Commander 680W; N940U Twin-Turbine Aero Commander 690B; N600WS Twin-Turbine Aero Commander 690A; N892WA Twin-Turbine Aero Commander 690A; N690EH Single-engine Piston Cessna TU206F; N603ET Single-engine Piston Cessna TU206G; N735BT Single-engine Piston Cessna TU206G; N2326B	Three (3) Vexcel UltraCAM Eagle Two (2) Vexcel UltraCAM D Two (3) MIDAS Oblique Sensors One (1) Visual Intelligence iOne n-Oblique Sensor One (1) Leica ALS-70HP Airborne LiDAR sensor

Pre-Acquisition Planning

Sanborn will carefully plan all missions to ensure that resulting data will be compliant with the requirements set for the project, and review our proposed flight and ground control plans with COAGA 2015 prior to mobilizing any field or airborne resources. Proposed plans will be provided to COAGA 2015 at least one week prior to mobilization. The following table presents our proposed acquisition specifications for the project.

Imagery Acquisition Specifications		
GSD	**3-inch**	**6-inch**
Proposed Sensor	UltraCam Eagle	UltraCam Eagle
Focal Length	100mm	100mm
Flying Height Proposed	4,732' AGL	9,464' AGL
Aircraft Speed	175 kts	175 kts
Sidelap	30%	30%
Endlap	60%	60%
Sensor Platform	Multi-Engine Fixed-Wing Aircraft	
Radiometry	4-band, 14-bit per channel RGB/NIR	
Acquisition Date	~1-March to 30-March, 2015	
Acquisition Time	~10am – 2pm	
Sun Angle	35 degrees or greater	
Conditions	Snow free, leaf off, no flooding, no ice on water bodies. No clouds, cloud shadows, haze, smoke, precipitation, or other ground obscuring conditions on more than 5% of imagery. Acquisition will not take place within 2 days after a rainfall of 0.5 inches or greater or within 5 days after a rainfall of 2 inches or greater	

Flight and Control Plans

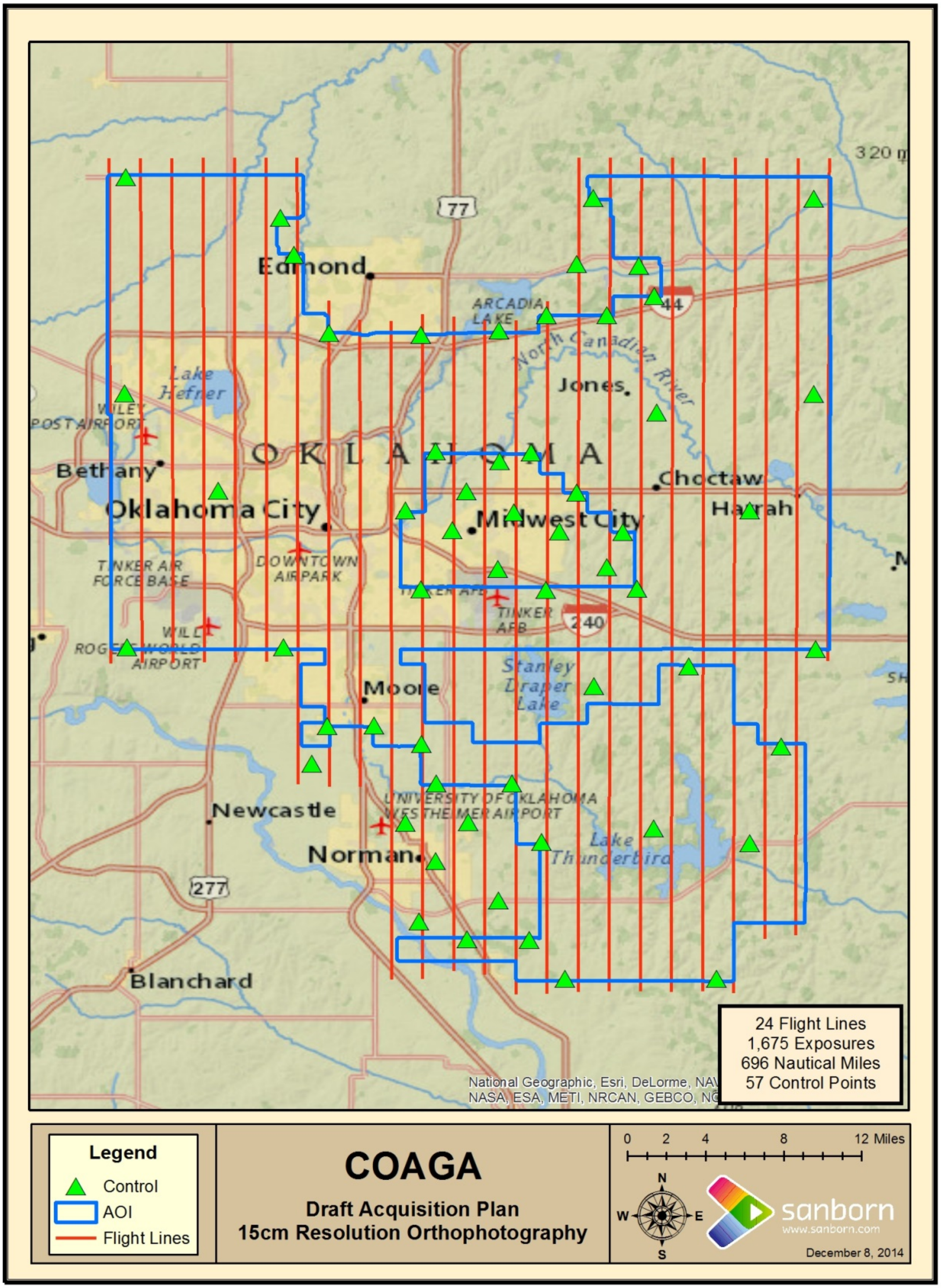
Flight planning and execution will adhere to ASPRS Draft Aerial Photography Standards. All flight and control plans will be reviewed by one of Sanborn's ASPRS Certified Photogrammetrists prior to their release. A summary of procedures and considerations in flight mission planning is as follows:

- Sanborn will prepare a digital flight line layout for the project area(s) using Track'Air software, taking into account the configuration of the UltraCam Eagle aerial camera, which we propose to use for this project, and the accuracy and resolution required for the imagery and other data products under the COAGA 2015's solicitation. These parameters determine the flight altitude, the footprint of each exposure on the ground, and correspondingly, the quantity of flight lines and exposures, and ground control requirements.
- Flight lines typically extend continuously across the project area. However, lines may be optimized in order to account for terrain, areas with tall structures, water bodies, airspace restrictions, and issues related to sun angle, lighting, and shadows.
- The Microsoft/Vexcel UltraCam Eagle will collect all imagery with 14-bits per channel in all 4 bands – Red, Green, Blue, and Near-Infrared. Our software enables us to orthorectify all four bands simultaneously, so there is no upcharge over collection and processing of 3-band imagery to deliver a 4-band orthorectified imagery product, providing added value to COAGA 2015, if the 4-band imagery is desired.
- The principal points of the first two and last two exposures of each flight strip will fall outside the boundaries of the area to be covered by the flight.
- In order to ensure sufficient coverage, Sanborn will plan imagery collection so at least 25% of each outermost line of images extends beyond the boundary of each area of interest.
- Forward lap and side lap will be as shown in Table 1 above, and will be adjusted as needed to ensure collection of quality imagery in areas with unique terrain or built infrastructure considerations.

- Sanborn's flight plan will contain the following information:
    - Projected flight lines
    - Flight line numbers
    - Intended coverage
    - Approximate number of exposures
    - Flight altitude
- Sanborn will overlay the flight line layout over Google Earth imagery, and determine optimum locations for the placement of ground control points, ground checkpoints, and GPS base stations, where these items are needed. Following COAGA 2015's approval, the control locations will be passed along to the project surveyor who will target, survey, and provide any other needed resources or information in support of the airborne acquisition mission.
- The final flight line map/photo index with photo centers will be delivered in Adobe .pdf file format, and in Esri Geodatabase format.

Draft Flight Plans

A copy of the draft flight plans is provided on the following pages.


Edmond
77
ARCADIA LAKE
44
North Canadian River
Jones
Lake Hefner
WILEY POST AIRPORT
OKLAHOMA
Bethany
Oklahoma City
Choctaw
Harrah
Midwest City
TINKER AIR FORCE BASE
DOWNTOWN AIRPARK
TINKER AFB
240
WILL ROGERS WORLD AIRPORT
Stanley Draper Lake
Moore
UNIVERSITY OF OKLAHOMA WESTHEIMER AIRPORT
Newcastle
Norman
Lake Thunderbird
277
Blanchard
National Geographic, Esri, DeLorme,
NASA, ESA, METI, NRCAN, GEBCO,
24 Flight Lines
1,675 Exposures
696 Nautical Miles
57 Control Points
Legend
Control
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Flight Lines
COAGA
Draft Acquisition Plan
15cm Resolution Orthophotography
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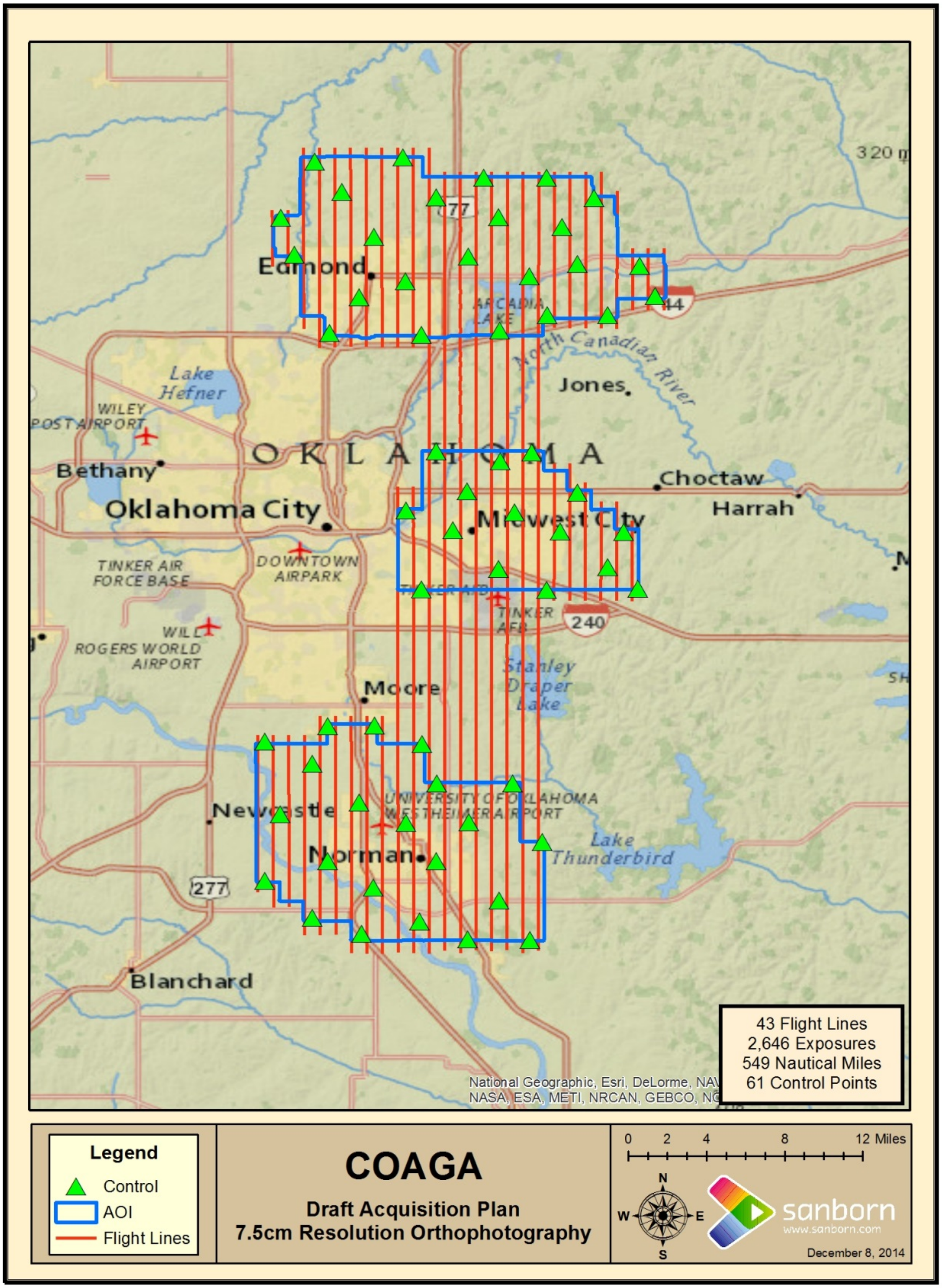
43 Flight Lines
2,646 Exposures
549 Nautical Miles
61 Control Points
Edmond
Arcadia Lake
North Canadian River
Jones
Lake Hefner
Wiley Post Airport
Bethany
OKLAHOMA
Oklahoma City
Choctaw
Harrah
Midwest City
Tinker Air Force Base
Downtown Airpark
Tinker AFB
Will Rogers World Airport
Stanley Draper Lake
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University of Oklahoma Westheimer Airport
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Draft Acquisition Plan
7.5cm Resolution Orthophotography
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Flying Conditions/Requirements

Our aerial team will monitor weather conditions and determine when to mobilize for the aerial missions. The optimal conditions occur:

- When the ground is clear of snow
- When the deciduous trees are barren
- When the air is free of smoke, atmospheric haze, fog, and dust
- When the air is free of clouds
- When the sun angle is 30 degrees or more above the horizon
- When streams are within their natural banks
- All photography will be accomplished roughly between the hours of 10:00 am to 2:00 pm to minimize shadows

Imagery will be rejected if clouds which impact the orthoimagery product are noted, or if the sun angle is less than 35 degrees, or if there are any other conditions which do not produce consistent, high-quality photography that clearly defines ground features.

Photography is accomplished by flight crews who will be temporarily based in the COAGA 2015 area in close proximity to the collection areas. We will attempt to acquire imagery in the shortest possible timeframe to minimize radiometric differences in the final image database.

Sanborn relies on a variety of sources to determine the suitability of conditions for acquisition. Our first and primary source is the flight crews and surveyors in the areas of interest. Flight crews are trained to observe and report the conditions as they see them on the ground and in flight. We will also coordinate with and defer to COAGA 2015 if there is any question regarding suitability of conditions. Finally, there are a variety of ways to observe conditions remotely, including NOAA weather reporting stations, daily weather satellite reports, weather video cams, and a variety of public sources that can be accessed for detailed observations.

Mobilization Planning

Sanborn will perform mobilization planning to ensure that airborne data acquisition can progress in accordance with the project schedule. This will include:

- Monitoring conditions to determine when the ground is clear of snow, leaf conditions of deciduous trees, and the conditions of lakes, streams and rivers.
- Monitoring sun angle in order to determine the time ranges in which flights can be conducted.
- Monitoring weather conditions.
- Locating airports at which to stage aircraft and aircrews, and arranging for their accommodations.
- Making arrangements to access restricted airspace, if needed. Sanborn will coordinate all flight plans with air traffic control (ATC) well in advance of mobilization.
- Ensuring that all needed ground control and base stations are in place prior to the flights.
- Monitoring GNSS satellite configuration

Mission Execution

Sanborn's aircrews will be mobilized to an airport near the project. The aerial team will monitor flight conditions and determine, in coordination with Sanborn's project manager and COAGA 2015, when to initiate imagery collection flights. Imagery will be captured for the entire project area at the required level of resolution. Mission profiles will be programmed into the Track'Air Flight Management System, which is integrated with the sensor systems on board each aircraft. This computerized system assists the aircrews with mission navigation and sensor operation, ensuring that imagery is collected in accordance with the flight plan. Aircrews are also able to mark flightlines or exposures where turbulence, clouds, or other factors that bear on the quality of the imagery may be an issue, so it can be accessed rapidly following the flight, and assessed for recollection, if necessary.

Operational Considerations

Sanborn's experienced aircrews are highly familiar with the airspace system in the region, and know how to navigate safely and efficiently within its boundaries. All flights will be coordinated with the appropriate civilian and military air traffic control authorities. Our aerial team has the relationships needed to gain access to sensitive and restricted airspace.

Sanborn's aircraft are equipped with all of the communication and navigation avionics required to operate safely in the federal airspace system. All of our aircrews are appropriately licensed and qualified, and our aircraft are operated and maintained in accordance with applicable Federal Aviation Administration regulations at all times.

While Sanborn does not anticipate any difficulty with regards to airspace access, our aerial team is prepared to make any necessary operational adjustments should airspace changes or temporary restrictions make them necessary. Possible steps to mitigate airspace issues include use of a sensor with a longer or shorter focal length lens, in order to enable operation above or below restricted airspace ceilings, or rescheduling or reconfiguration of flights. Sanborn will provide immediate notification if any of these steps become necessary.

Post-Acquisition

Flight Logs will be prepared following each mission. The pilot or system operator will prepare a flight log for each flight day containing the date, project name, aircraft used, and names of crew members. In addition, the following information is recorded for each flight line: altitude, sensor number and any other comments relative to the flight conditions. These flight logs will be submitted digitally. All AGPS, IMU, and image data will be downloaded the day of collection. Preliminary processing of the ABGPS data is performed to ensure the data is complete and produces accurate photo center coordinates.

Status Reporting

Sanborn requires flight crews to submit a daily status report by fax or email immediately after that day's operations to the Sanborn acquisition manager. The report states what occurred during the day. If the crew didn't fly, they report why. If they did fly, they report what was flown, the weather and ground conditions, and the expected image quality. In both cases, they also provide a prediction for the next day's operations.

After receiving the reports from the field, the Sanborn production office in Colorado Springs will compile the results into one daily status report to send to Sanborn's project manager. This report will be reviewed and sent to COAGA 2015 on a daily basis.

In the past, this simple reporting system has proven highly effective. It is simple enough to not burden the flight crews, flexible enough to handle field contingencies, and effective enough to communicate the essential details to COAGA 2015.

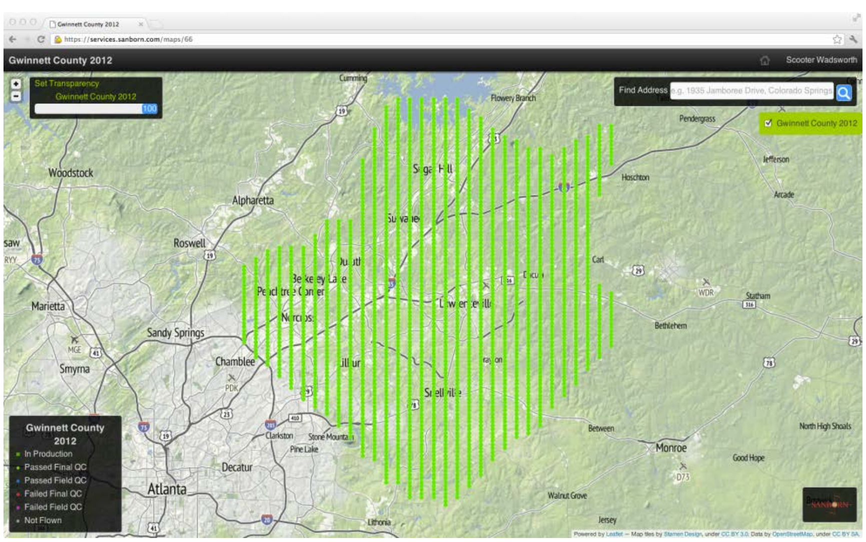
Online Flight Status Tool

Sanborn has recently developed an online status tool which would be used to report flight status during the acquisition process. The online status tool will update each morning, and will complement the shapefile and reporting information provided daily by the Sanborn project manager. The status tool will display the updated version of the flight plan shapefile(s) indicating which frames have been captured, reviewed, and/or accepted.

COAGA 2015 can identify the specific stakeholders that they would like to have access to the online status tool. With a unique login, stakeholders have the ability to access the acquisition status at their own convenience. This tool facilitates the sharing of the project information between Sanborn and COAGA 2015's stakeholders.

This technology will benefit this project and COAGA 2015's project manager by:

- Providing easy distribution of acquisition status updates, alleviating reliance on email or phone calls
- Providing information in a format accessible from any internet connected device
- Providing access to multiple COAGA 2015-approved stakeholders simultaneously, which will relieve COAGA 2015's project manager from answering calls from stakeholders regarding status.



Sanborn Online Flight Status Tool

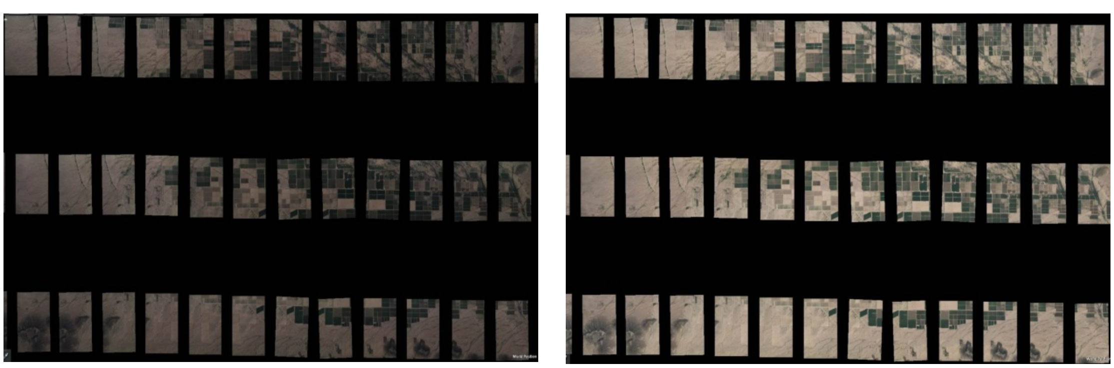
Image Processing and Radiometry

The imagery and peripheral data sets will be downloaded from the on-board data storage system, backed up, and shipped via overnight courier to Sanborn's production facility in Colorado Springs, Colorado. Upon receipt of the newly-collected imagery by the production office, the digital image processing phase is initiated. The following characteristics exist in all camera systems. While each system type has slight variations, all digital frame sensors are fundamentally similar in the way imagery is recorded and processed into useable data.

Each system uses an array of Charged Coupled Devices (CCD) to record panchromatic, RGB, NIR values. Once the images are acquired by each sensor, the imagery and mission parameters are stored in a raw binary format on the flight hardware. Each sensor uses a series of portable hard drives which can be linked to the aircraft-based servers; upon landing, the imagery is downloaded to the portable drives. Once the imagery has been transferred via the portable hard drives to a production facility, post-processing begins. The array of CCD's requires post processing of each individual frame in order to mosaic together a single large format image. Each sensor type has a slightly different CCD layout, but the final frame image is a 4-band, 12-bit image.

Upon receiving the "raw" image data from Sanborn's flight operations, it is downloaded to the server to initialize processing in the Microsoft UltraMap software. Using UltraMap Raw Data Center, the "raw" image data is processed to a Dragon Fly Project file (.dfP) of the imagery which allows image processing technicians to view and manipulate each imagery mission. The .dfp file is then loaded in the UltraMap AT software in order to run Project Based Color Balancing (PBCB) on the images. PBCB uses tie-point collection which samples the histograms of all images in a block to produce a color balanced set of images. Imagery missions can be merged to provide a continuous color balance across the entire project. After PBCB is ran, the .dfp file is opened in UltraMap Radiometry. UltraMap Radiometry provides tools for detailed and specific radiometric adjustments to the imagery to eliminate such things as hotspots, atmospheric effects, and haze. There are also tools to adjust the gamma, histogram levels, haze, and exposure of the imagery. All adjustments are made while the imagery is still at a 12-bit color resolution allowing for the greatest quality when converted to 8-bit deliverables.   After color balancing is complete the final step is to process out the images to the desired final product. UltraMap provides options for the output type of the Images. These options in include image Mode (RGB, RGBI, CIR, etc.), resolution, file format and Bit Depth (8/16 bit).

In addition, during QA/QC, each image will be displayed and checked for completeness, radiometric acceptance, and any obvious visual problems. Any cause to reject the image will justify the need for a re-processing or re-flight of that particular image. Only after images have been displayed, checked, and accepted will they be released for use in subsequent production procedures.



Before and after Project-Based Color Balancing

Photography Quality Control

Sanborn takes every possible measure to ensure that mission planning, operational conditions, precision aerial cameras, and computerized flight management systems all work together to result in the acquisition of high quality, error-free imagery for the project. We quality check the entire imagery data set three times before accepting it for exploitation.

As each image is acquired, a snapshot of that image is visible to the aircrew on a monitor. Our photographers view this snapshot at the time of capture and then again post-mission, before sending the imagery to the office. Sanborn's photographers identify over 98% of the re-flights in the field through this QA process.

When an imagery data set arrives at the office, it is immediately backed up. Thereafter, it is processed to the final image. This processing occurs quickly, as dedicated, high-capacity workstations utilizing a distributed processing system are used for the task. After the imagery is processed, a technician reviews the imagery a third time. The technician looks for details which may not have been visible in the snapshot and confirms that the image processed correctly. Checks performed by the technicians include:

- Review of the imagery for density, contrast, hot spots, clarity, shadow and highlight detail, and overall quality.
- Technicians will also check each line of imagery for:
  - Adherence to the flight plan—the editor will review the imagery to ensure that the specified flight plan has been successfully executed.
  - GSD—the technicians will confirm that the specified GSD has been achieved.
  - Departures from flight heights required to produce the desired image scale shall not exceed minus two percent (-2%) or plus five percent (+5%)
  - Crab— Crab in excess of three degrees (3°) may be cause for rejection of a flight.
  - Tilt and Tip— Tilt of the camera from vertical at the instant of exposure shall not exceed three percent (3%), nor shall it exceed five percent (5%) between successive exposure stations. Average tilt over the entire project shall not exceed 1%.
  - Forward overlap—the forward overlap will be examined to ensure that it falls in the appropriate range for each acquisition area.
  - Side overlap—the side overlap will be examined to ensure that it falls in the correct percent range for each acquisition area.
  - Anomalies—any other anomalies that could affect the final product will be examined, such as exposures settings, pixel drop out, etc.

If the technicians identify the need for any re-flights, they immediately email the flight crew needed parameters. Our goal is to accomplish this review within three days of acquisition of the photography. Sanborn understands that unacceptable imagery will be re-flown at no additional cost to COAGA 2015. All re-flight coverage will overlap the accepted imagery by at least two exposures, and will be captured using the same sensor type that performed the initial acquisition.

Proposed Sensor Technology

Sanborn has fully implemented digital aerial camera technology and adapted our workflows to maximize the benefits of these systems. Sanborn was one of the first companies in the United

States to purchase and operate large-format, metric digital aerial cameras, and over the intervening years, has developed extensive expertise in the implementation and use of digital camera technology. We have worked closely with manufacturers to ensure that our workflow, from acquisition through image processing, supports our subsequent production processes, and Sanborn has been integral in the manufacturer's development of improvements to their technology. Sanborn has been working with the Vexcel Systems (now the Microsoft Photogrammetry Division) since 2004, following our initial acquisition of their UltraCam D camera system. In total, Sanborn has used digital aerial cameras for over 3,000,000 square miles of imagery collection and processing for clients across the United States. A description of the sensor system, as well as quality assurance measures taken to ensure its readiness for use on a project is outlined below.

The Microsoft/Vexcel UltraCam Eagle Digital Aerial Imagery Sensor

Sanborn procured the third-generation Microsoft/Vexcel UltraCam Eagle digital aerial imagery sensor, which it proposes for this project, in February, 2013. The features and benefits of this system include:

- State-of-the-art CCD technology, 14-bit dynamic range, and a lower signal to noise ratio, resulting in nearly twice the brightness values of the sensors previously used for imagery collection by Sanborn, and providing exceptionally sharp, high-quality imagery even in less-than-ideal weather/atmospheric conditions, and better interpretability in areas where shadows are unavoidably present.
- A 5.2 µm pixel size at the sensor, compared to 12 µm for the Intergraph DMC sensor it has replaced. This allows Sanborn to collect imagery at much higher altitudes than was previously possible, while still meeting the accuracy and resolution requirements set for a project.
- The higher imagery collection altitudes made possible by the UltraCam Eagle minimize air traffic control/airspace incursion issues, and result in a much larger (~2.5x DMC) exposure footprint on the ground. This translates to a smaller number of exposures needed to cover a project area, faster collection times, less ground control, and lower cost to COAGA 2015.
- Utilizes the best optics module currently available on the market. Additionally, the 100mm lens system provides a broader "central perspective", resulting in less radial displacement (e.g. "building lean") in the image data.
- Based upon proven, stable, frame sensor technology that results in maximum operational reliability and the most precise image geometry. In contrast to "push-broom" or line sensors that are completely reliant on the AGPS/IMU technology to generate usable data, normal photogrammetric solutions can be applied to the UltraCam Eagle's imagery, enabling normal use of that imagery in the event of problems with the AGPS/IMU sub-systems. While Sanborn operates the best GPS/IMU systems available and failure is unlikely, this mitigates operational risk to Sanborn and COAGA 2015.
- Forward Motion Compensation (FMC) implemented through TDI (Time Delayed Integration) technology.
- Solid state, in-flight exchangeable data storage modules result in higher reliability and longer mission times.

- Suitable for a wide range of applications, from large-scale engineering mapping to low-resolution remote sensing projects.
- Outputs image data in industry-standard file formats can be ingested into and processed with any standard softcopy photogrammetric system on the market
- Can be operated within a wide range of flying heights, and is operationally suitable for operation in both pressurized and unpressurized aircraft.
- Utilizes a modular hardware design, which enables easy replacement or upgrade of components. This includes field replacement of the lens system, enabling utilization of different focal length lenses.
- Extremely rugged camera frame and peripheral hardware design, leading to maximum operational reliability. Constructed of high-grade industry components for safe and reliable aircraft installation (high grade connectors, environment tests against DO160, a minimum of cable connections, crash load tests against DO160) and operation.

The gyro-stabilized camera mounts in Sanborn's aircraft were upgraded to the latest Track'Air systems at the same time as the UltraCam Eagle sensors were acquired, and represent the most advanced technology currently available on the market, ensuring a stable camera platform and high-quality imagery even in the event of unexpected, turbulent flight conditions.

Technical Specifications for Sensor

Technical specifications for the UltraCam Eagle are as follows:

Microsoft/Vexcel UltraCam Eagle Specifications	
High-resolution 20K x 13K Panchromatic camera:	Final output image is 20,010 x 13,080 pixels
Field of view:	66° cross track x 46° along track
Panchromatic camera lens system:	f = 100mm 1/5.6 or f = 80mm 1/5.6 Shutter speed 1/500 to 1/32 sec
Multispectral 6.7K x 4.4K cameras (x4):	red, green, blue, and near infrared each 6,670 x 4,360 pixels
Multispectral camera lens system:	4: x f = 33mm/f: 4.0 or f=27mm/f: 4.0 Shutter speed 1/500 to 1/32 sec
Physical pixel size:	5.2 µm
Input data quantity per image:	842 megabytes, 260 megapixels
Maximum frame rate:	<1.8 seconds per frame
CCD signal to noise ratio:	72 dB
CCD image dynamic range:	14 bit; workflow dynamic: 16 bit
In-flight data storage system:	Solid state disc pack, Capacity ~3.3 TB, ~ 3,800 images per swappable unit
Time needed to swap disc pack inflight:	Less than 2 minutes
Data recording time @ 10 cm GSD, 60% forward overlap, 140 kts:	8 hours per disc pack

Radiometric and Geometric Calibration

In order to facilitate collection of imagery with the best possible radiometric and geometric properties, Sanborn ensures the completion and currency of two independent camera calibration/verification processes. The first laboratory calibration is performed by the manufacturer. The second is Sanborn's internal camera calibration/verification procedure. Sanborn will provide current manufacturer calibration certificates for all sensors used on the project, as well as a report based upon Sanborn's own methods and procedures to verify the accuracy of any sensors used on the project. For example, each time a camera is installed in an aircraft, a complete geometric calibration is performed in order to ensure the accuracy of the platform. This process is referred to as a "boresight."

Manufacturer Calibration

Prior to delivering a digital sensor to Sanborn, the manufacturer performs the following calibration procedures.

- **Geometric calibration:** The geometric calibration is based upon a set of 84 images of a defined geometry target with 240 control points. The number of point measurements is over 60,000. This calibration procedure guarantees that the remaining lens distortions are less than 0.002 mm.
- **Verification of lens quality and sensor adjustment:** The targets used for the geometric calibration also hold resolution targets, which are used to derive the modulation transfer function (MTF) across the field of view of camera. The MTF is derived for the meridonial (tangential) and sagital (radial) component of signals at frequencies of 10, 20, and 40 line pairs per millimeter for various aperture settings. The MTF is guaranteed to be less than -7dB in the field of view that typically is used for mapping applications, even for the 40 line pairs per millimeter resolution.
- **Radiometric calibration:** The radiometric calibration is based on a series of 60 flat field images for each aperture size and sensor. The flat field is illuminated by two normal light lamps with known spectral illumination curves. These images are used to calculate the specific sensitivity of each pixel to compensate local as well as global variations in sensitivity. Sensitivity tables are calculated for each sensor and aperture setting, and applied during post processing from level 0 to level 1. The resulting image has virtually no vignetting caused by the camera system.
- **Calibration of defective pixel elements:** Outlier pixels that do not have a linear behavior as described in the CCD specifications are marked as defective during the calibration procedure. These pixels are not used or only partially used during post processing and the information is restored by interpolation between the neighborhood pixels surrounding the defective pixels.

Sanborn's Camera Accuracy Testing

Sanborn's image quality criteria require consistent and homogeneous imagery devoid of response gradients and vignetting within an exposure, and unnatural tonal variations across exposures. To ensure that these criteria are met, Sanborn employs a four-step radiometric calibration and processing method. These steps are:

- **Pre-Flight Calibration:** Camera response is calibrated the day of acquisition for the ground reflectance and expected illumination conditions. The calibration process ensures maximum use of the available 14-bit dynamic range and correct color balance. An advantage of the Eagle camera is the ability to respond to changing flight conditions. Camera settings can be changed by the operator within a flight line if required to ensure quality imagery collection.
- **Atmospheric Correction:** Atmospheric correction removes any haze or atmospheric transmission loss using a Modtran4 derived correction function.

- **Sensor Corrections:** Pre-processing to remove any vignette effects producing a homogeneous exposed image.
- **Color Balancing:** Final processing includes local and global color balancing to ensure all image exposures appear to be taken at the same time with no tonal variation across seams.

Geo-referencing

Sanborn's approach will be to utilize existing, available control points, augmented with newly surveyed ground control points where needed, together with AGPS/IMU-controlled aerial photography to accurately control the Fully Analytical Aerial Triangulation (FAAT) solution. Airborne GPS/Inertial Measurement Unit (AGPS/IMU) data will provide primary support for image positioning and orientation, minimizing the required number of ground control points required, while still enabling the creation of orthoimagery and other mapping products that conform to the accuracy standards set by COAGA 2015 for the project.

Reference System

Sanborn will ensure that all land survey and airborne GPS/IMU data collection and processing procedures generate control coordinates that result in an aerotriangulation solution that accurately georeferences all deliverable data in the appropriate Oklahoma State Plane Coordinate System Zones. The horizontal datum will be the most current NAD83 Realization, presently NAD83(CORS96); epoch 2002.0. All vertical control will be referenced to the National Geodetic Vertical Datum of 1988 using the most current NGS Geoid Model, presently GEOID12A. The unit of measurement will be the US survey foot.

Airborne GPS / Inertial Measurement

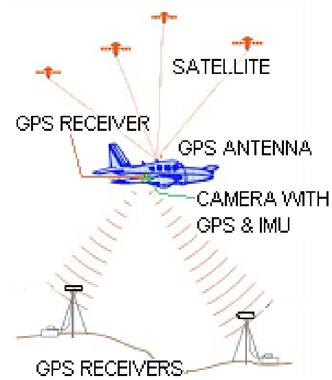
The Microsoft/Vexcel UltraCam Eagle digital camera system utilizes airborne GPS (AGPS) and inertial measurement unit data (IMU) as input for sensor positioning and exterior orientation development. Sanborn's new Applanix Type 46 Non_Itar IMU's, acquired early in 2013 as part of our sensor modernization program, will be used to manage and collect data for this process. Novatel Millennium DL4+ dual frequency GPS receivers collecting P-code pseudo range and L1/L2 carrier signals at a sampling rate of 2 points per second will be used in the aircraft to collect GPS data.

These directly observed exterior orientations will be combined with conventional ground control in an AT bundle adjustment. The statistics derived from the bundle adjustment will provide an accuracy assessment for ortho rectification and/or stereo compilation. The use of AGPS/IMU data has a number of benefits:

- It allows more flexibility in the selection of ground control points, making it possible to work around difficult areas such as forests, private land, restricted areas, and water bodies.
- It enhances the overall reliability of the AT solution.
- It results in bundle block adjustments of greater accuracy and homogeneity.
- Depending on the mapping products, it allows some level of reduction in the amount of ground control, enhancing production schedules.

It automatically determines all six of the parameters required for resolving the exterior orientation of each photograph and allows for more reliable and accurate results from assisted automatic aerotriangulation.

General AGPS Procedures



Sanborn's airborne GPS approach will consist of the following steps:

- Recovering or establishing suitable base station locations within the project area, as appropriate to the accuracy specifications for the project.
- Validating the bore-sighting of the camera and AGPS system. AGPS/IMU boresight calibration is performed at least twice per year. Any time the camera or AGPS/IMU is moved, a new boresight is required.
- Collecting, processing, and interpolating the AGPS data to derive camera station coordinates and rotations at each instant of exposure

During the mission planning process, Positional Dilution of Precision (PDOP) is evaluated using Trimble's Qplan or Ashtech's MPwin GPS planning software. All mission collections will be conducted with a PDOP of 3.2 or lower. The KP index is also evaluated prior to mission collection. KP index is a measurement of geomagnetic activity at the earth's surface that can greatly affect the GPS solution. Therefore, no collection will occur when the KP index is at or above 4.

Prior to the actual AGPS photography missions, Sanborn will also check the AGPS system installation. This involves:

- Checking the GPS antenna location on the aircraft
- Checking the GPS receiver to aerial camera connections
- Re-measuring the offset vector from the antenna to the camera's front lens node

Base Stations

Due to ABGPS/IMU technology used by Sanborn, base station distances are not limited to traditional 55km baselines. During the data acquisition missions, multiple National Geodetic Survey Continually Operating Reference Stations (NGS CORS) that are up to 200km from the acquisition area will be logging 1, 2, or 5-second data that will be download and incorporated when processing the airborne GPS solution. In order to ensure mission integrity, Sanborn will be operating base stations (Trimble 4100 or 5700 receivers) on the ground in the proximity of the project area for the duration of the acquisition flight as a backup in case of any failures or problems with the CORS system.

Typically, at least 1 GPS base station will be in operation during each mission. This GPS receiver will be set on a published National Geodetic Survey control point such as the Primary Airport Control (PAC) Station. If for any reason it not be possible to set a GPS base station at a published NGS point, a temporary point will be introduced and marked near the FBO (fixed base of operation) at the airport of departure.

The base station receiver at the airport will be operational prior to starting airborne data collection. All crews will have their base station(s) running at least 7 minutes prior to sun angle and at least seven minutes after sun angle. This provides redundant base station data in the event of a base station failure or other unanticipated GPS issue from one crew. All GPS receivers will be set to an epoch rate of 2 Hz.

In-Flight Calibration

The AGPS/IMU system requires a seven minute "initialization" period for satellite data acquisition prior to takeoff. This seven minute time period will not begin until after the system has been started and data logging has begun. After landing and when the aircraft is stationary, the AGPS/IMU subsystem will continue to collect data for seven more minutes. This procedure ensures that the airborne GPS unit is functioning properly and the solution is fixed. The initialization and termination of the aircraft's data collection will occur as close to the airport base station as possible, but far enough from buildings to prevent multi-path errors.

The ground and airborne GPS receivers will collect data at half- second epochs for the duration of all missions. Aircraft will not be banked more than 20 degrees during data collection to prevent loss of lock with GPS satellites.

AGPS Post Processing Software

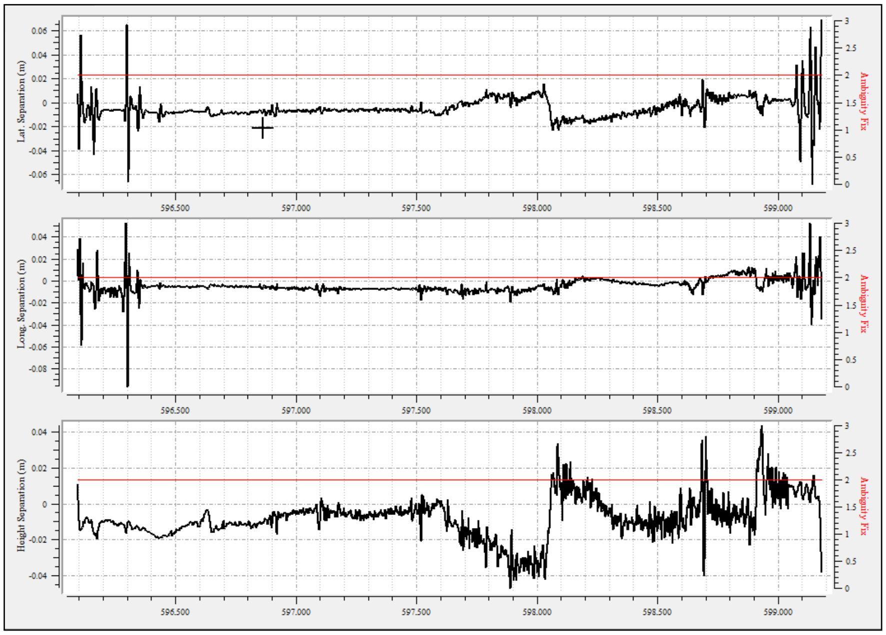
All AGPS/IMU data will be downloaded from the aircraft the day it is collected. Sanborn will use the latest version of Applanix MMS kinematic AGPS post-processing software (currently v6.2) to process all AGPS/IMU data. Sanborn has been using this software since 2008. Applanix MMS software has numerous benefits, including:

- It exports into the proper format for direct input into the Inpho Match-AT software
- Numerous visual displays are available to assess systematic errors as well as to ensure that the requisite accuracy is met

In a combination of AGPS data, the expected accuracy of the orientation of the photo exposures will be 0.10 meters in position and approximately 20 to 30 arc seconds in tilt, roll, and heading. Once a final solution is achieved, the photo center coordinate positions will be exported in the project coordinate system in preparation for use in aerial triangulation (AT).

Airborne GPS QA/QC

Sanborn rigorously checks the quality of the processed airborne GPS and INS data before implementing it into the bundle block adjustment. The kinematic data are processed from a minimum of two base stations, and the solutions are compared. This procedure verifies the integrity of the base station coordinates and elevations. Each processing session is computed in both the forward and reverse temporal directions. The comparison of these solutions provides insight into the quality of the kinematic ambiguity resolution. The below figure illustrates a high quality combined solution - positional information predominantly within the range of 4cm.



Once a final solution is achieved, the photo center coordinate positions will be exported in the project coordinate system in preparation for use in aerial triangulation (AT). Sanborn will supplement the final AT report with a section addressing the AGPS/IMU component of the acquisition. The information provided will include at a minimum:

- An analysis and write-up of the AGPS/IMU collection procedure, processing, and results
- An index identifying each image, corresponding digital file name, and image acquisition date and time in Esri .shp format.
- All photo centers (X,Y,Z) and the IMU unit rotation values

Delivery of Raw Imagery

Following completion of final QC checks, Sanborn will deliver the raw imagery and associated data to COAGA 2015. This will include:

- The raw stereo imagery with its original spectral and spatial resolutions intact. Each image will be delivered as a single 4-band R/G/B/NIR stack at 14-bit resolution.
- Delivery format will be geo-referenced JPEG 2000 files (.jp2). Geo-referencing will be based on the GPS/IMU position/orientation data recorded during flight, and will be supplied in the header of each image file and as a world file (.j2w) for each image.
- An index identifying each image, corresponding digital file name, and image acquisition date and time in Esri shapefile format.
- The airborne-GPS photo center locations (X,Y,Z) and the inertial measurement unit rotation values (ώ,φ,ϰ) with units for all parameters documented.

Sanborn understands that raw imagery deliverables are expected within thirty (30) days of image capture.

Ground Control Surveys

Mr. Steve Wood, registered Oklahoma PLS will perform and certify the ground control survey. While Airborne GPS and IMU technology will serve as the primary means for geo-referencing, a framework of ground control is needed to serve as checkpoints and to enhance the control solution. Aerial control or ground checkpoints will be photo-identified or targeted as needed by Sanborn. New control will be established where control from previous projects is unavailable or unrecoverable.

Example of a photo ID control point (intersection of driveway with sidewalk) that could be utilized.

Example of a targeted control point

New Control

Where new control is needed, Sanborn's survey team will perform reconnaissance to determine optimal locations for its placement. Criteria for selection include:

- **Suitability**—for photogrammetric ground control, including good contrast between the ground surface and target material, and a flat ground surface.
- **Safety** – Protection or shielding of targets from disturbance or destruction. Safety of equipment and personnel
- **Recoverability**—ease of recovery
- **Accessibility**—for occupation by GPS and other surveying equipment
- **Locality**—within public rights of way or easements or on public property, where feasible
- **Compatibility**—potential conflicts with future development, including the construction of new highways
- **Visibility** – locations that allow an open and unobstructed view to the sky

Monumentation

Newly surveyed points will be semi-permanent, and will either be 5/8" rebar with an aluminum cap, or PK nail with and aluminum washer. The intent of these survey monuments will be to meet analytical aerial triangulation and check point requirements only.

Targeting

Using control point coordinates and/or shape files along with GIS base layers, a location map will be generated for each control point. Survey field technicians will use these maps to reach the vicinity of each point, and then use either mapping grade or RTK GPS units to pin point the monument location. The target placement will be documented with at least three photos: a close-up of the monument, a full frame of the target, and landscape features surrounding the target.

All targeted ground control points will be paneled with material of sufficient color and size to enable ease of identification in the aerial imagery, and use in the aerial triangulation process. Targets may be of an “L”, “V” or "X" shape. Painted targets will be placed using pre-fabricated templates and water-based paint. Plastic target material will be used on unpaved surfaces. The Sanborn team will remove all targets upon successful acquisition and notify COAGA 2015 when this task is complete.

Control Specifications

All GPS surveys will meet the accuracy standards of at least order C-2-II as defined in “Geometric Geodetic Accuracy Standards And Specifications For Using GPS Relative Positioning Techniques”, Federal Geodetic Control Subcommittee, August, 1989. Accuracy will be reported according to the “GEOSPATIAL POSITIONING ACCURACY STANDARDS Part 2: Standards for Geodetic Networks developed by the Federal Geodetic Control Subcommittee (FGCS) and the Federal Geographic Data Committee (FGDC)”, 1998.

Surveying Methods: Horizontal and Vertical Control

A GPS Static and Fast Static control network forms the backbone of all location surveys. Sanborn has extensive experience in designing, processing, and adjusting large control networks, and with the coordinate systems on which they are based.

Sanborn has reviewed COAGA 2015’s requirements for survey control, and will ensure that survey operations result in the establishment of control that meets these specifications. A high level of redundancy will be maintained between baselines on all primary networks. Reliability of point positions that have redundant base lines and can be adjusted within a network is stronger than points observed using non-redundant RTK techniques.

Sanborn will submit a control plan prior to proceeding with fieldwork that shows the location of stations to be observed with baselines to be observed during each session. Once targeting is complete, Sanborn will design a final control network which includes all new monuments as well as sufficient HARN monuments to hold as fixed points. Any network or sub-network in a survey will consist solely of independent, non-trivial baselines. Only processed baselines that have fixed ambiguity resolutions will be included in a network.

GPS Data Acquisition Techniques

A two to three person survey crew equipped with differential dual-frequency GPS units will make GPS observations on the network to provide coordinates of the new points. All observations will be conducted with a minimum of 4 observable satellites and maximum PDOP of 7. Data for fast static sessions will be collected for a minimum of 10 minutes at a sampling rate of 15 seconds. All field notes, sketches, adjustments, positional closures, and electronic files for all control and photo control GPS network points will be submitted in the final survey report.

Each new control point will have two or more independent station occupations. Independent occupations will have tripods reset and re-plumbed between sessions. Sessions will be separated by at least twenty (20) minutes.

All GPS surveys will meet the following minimum accuracy standards:

- Independent observations on new control points must agree within 0.08-foot in X and Y
- Observations on existing control of a higher accuracy must agree with the published coordinates within 0.08-foot in X and Y
- Independent observations on new control points must agree within 0.15-foot in Z
- Observations on existing control of a higher accuracy must agree with the published coordinates within 0.15-foot in Z

Antenna Setup—Sanborn will measure the antenna height twice at each setup: once in meters and once in feet. The two measurements will be reduced to a common unit system and compared in the field before leaving the station. This approach eliminates the possibility of observing an incorrect instrument height.

Baseline Processing—all baseline vectors will be post processed nightly using Trimble Geomatic Survey™ software. Fixed bias, double-difference solutions will be determined for all selected baselines. Baselines that do not produce an acceptable solution will be discarded and re-observed on the following day.

Loop Misclosure Analysis—Loop misclosures for all figures in the network will be computed and analyzed on a daily basis. They are the first major indicators of quality, and will be tabulated and compared with the FGCS guidelines. Misclosure table will be included in the Final Survey Report for quality assurance purposes.

GPS Network Adjustments

Minimally Constrained (Free) Network Adjustment—After each day of fieldwork, the complete set of quasi-independent (nontrivial) baselines will be combined in a rigorous, minimally constrained, least squares adjustment. To facilitate the adjustment, the geodetic latitude, longitude, and ellipsoidal height of one existing station will be held fixed.

Sanborn will use Star*Net™ or similar software, which is a three-dimensional least squares adjustment package. The variance-covariance terms from the baseline solutions will be scaled to ensure realistic observation weighting. The estimated (a posteriori) reference variance will be tested using the chi-squared test while the Tau-maximum test will be used for outlier detection. These tests are a direct form of quality control. Baseline component residuals will also be carefully examined.

Sanborn's approach allows for continuous quality assessment, which ensures the attainment of the required accuracy specifications. Analysis of the quality of the network will be based on these criteria:

- Accuracy Classification—all directly connected 95 percent relative error ellipses from the minimally constrained adjustment will be analyzed. This examination ensures maintenance of the required internal (relative) spatial accuracy. The network will be deemed acceptable when the relative positional accuracy between all pairs of stations does not exceed Second Order as defined by the FGCS.
- Station Confidence Regions—the station confidence regions will also be computed via the minimally constrained least squares adjustment. Examination of these results will reveal the expected horizontal accuracy of each station. Given achievement of the proposed FGCS relative positional accuracy, the final horizontal coordinates of the ground control will be more than sufficient to support the accuracy requirements for this project.

Survey Report

Upon completing the ground control phase, Sanborn's ground control team will prepare and submit a Final Survey Report in .PDF format. At a minimum, the report will provide the following information:

- Executive summary of the survey and its results
- The location and extent of the network
- A narrative description of all aspects of the surveys
- Equipment and software details
- Tables summarizing the GPS misclosures.
- Results of the minimally constrained (free) adjustment and the formal classification of the network in terms of the relative spatial accuracy
- Results and associated analysis of the constrained least squares adjustment
- Final coordinate listings
- A network diagram, showing all stations and the measured quasi-independent baselines
- Reference sheets for all ground control points

Permissions, Public Relations and Safety Issues

Sanborn is aware of potential concerns that some members of the public may have regarding field survey operations. Sanborn will ask COAGA 2015 for a letter explaining the intent of the survey that can be referenced in the event of queries from the public. All field personnel will dress and conduct themselves in a professional manner. Sanborn will conduct field operations during daylight hours, and observe all laws and regulations pertaining to operations in public rights-of-way, as well as entry to public or private property.

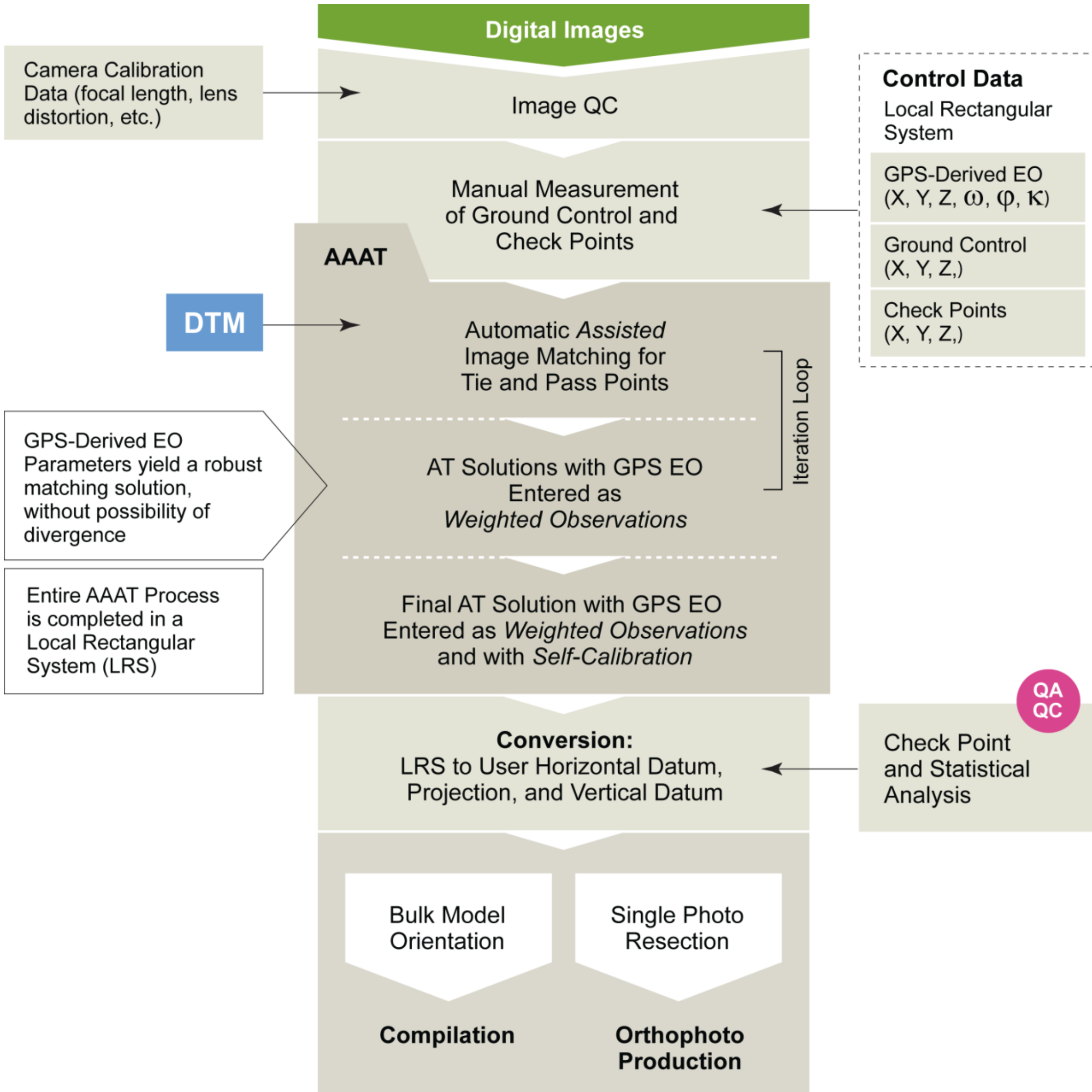
Ground Survey QA/QC

The control survey will be characterized by extensive quality control mechanisms, for example:

- Dual instrument height measurements using different units of measure, or fixed-height tripods.
- Use of redundant, quasi-independent GPS baseline in all loops; loop misclosures
- Least squares adjustments and statistical evaluations
- Use of multiple well distributed existing horizontal and vertical control points as the basis for the new network(s)
- Independent review and checking of all computations
- Supplementing GPS surveys with conventional survey techniques using electronic traversing (total stations) and digital leveling for more precise vertical control.
- Full reporting of all results and the inclusion of all computations, field logs, solution printouts, and any other pertinent information provide quality assurance.

Digital Aerotriangulation (DAT)

Once the processed imagery, ABGPS/IMU, and ground control survey data become available, Sanborn's next step will be to complete Aerial Triangulation (AT). Carefully developed and refined procedures will be followed, as the AT solution is the foundation for the accuracy of all derivative data products created from the imagery. Each stereo model will contain between 60 and 120 pixel match points to ensure that the relative accuracy and measurement integrity of the entire block of imagery is achieved. Sanborn's procedure consists of the use of a fully automatic pixel-matching routine, followed by a supervised, manual point selection, introduced strategically where automated routines have difficulty matching pixels (shadows, water, dense trees, etc.). A flow diagram outlining Sanborn's aerial triangulation approach is shown below, and described in the following paragraphs.



Assisted Automatic Aerial Triangulation (AAAT)

AAAT is a refinement of conventional AT in which airborne GPS/IMU data are used for the direct measurement of the position and orientation of every exposure in the photogrammetric block. These data result in highly reliable automatic tie point and pass point measurements, because the directly observed exterior orientation data prevents divergence of the solution. The AAAT process improves upon conventional (manual) aerial triangulation by providing numerous automated tie points and pass points. Sanborn will automatically measure seven or more tie points and pass points in each of the standard Von Gruber locations. The automation of manual point observation within the AT process introduces significant efficiency when adjusting large contiguous blocks.

The benefits of softcopy-based AAAT include:

- Alleviation of the need to perform manual pugging and observation of control points, tie points, and pass points.

- Much greater productivity, a factor that is crucial to schedule adherence and minimizing cost to COAGA 2015.
- Improved accuracy, because the procedure yields many more tie points and pass points than could be practically observed by manual means.

Sanborn will use Inpho's Match-AT software to perform AAAT. On the market since 1996, and in its current version, offering what we believe to be the most evolved aerotriangulation solution available, Match-AT has a proven track record on projects of similar size and scope. The graphical display of adjustment statistics via this software is a highly valuable aid for analysis and quality control. Verification of results and measurement of ground control and check points will be performed using the Match-AT module as well. Match-AT includes bundle block adjustment module which performs least squares block adjustment after automatically matched points are generated and manual measurements are completed. Software has built in tools to flag and eliminate blundered observations.

The benefits of using Inpho's Match-AT software include:

- Match-AT enables the AT technician to use refinement to enhance the matching of a selected point in neighboring images during the mensuration of control and supplementary tie points. Sub-pixel accuracy is achieved on a routine basis.
- Match-AT provides a seamless digital environment because the AT result (namely, the final bundle block adjustment result) is applied directly, yielding single photo external orientations and absolute orientations, which can be used immediately in photogrammetric data capture and orthophoto by using Match-AT's export functions to convert data to be used in data capture and orthophoto production modules.

Absolute Accuracy Check Points

True verification of accuracy requires the use of independent check points – specifically, ground control points withheld from the AT process and used as checks after the initial adjustment. To meet statistical criteria via a sufficiently large sample, Sanborn typically withholds a minimum of one-fourth of the ground control points to be used as check points to verify the quality of the AT adjustment. Since AGPS/IMU will be relied upon as the primary element of control for this project, ALL ground control points may be withheld in order to generate an RMSE for all ground control against an independent AGPS/IMU solution. This process validates the AGPS/IMU as a stand-alone solution for meeting the specified project accuracy. A final AT adjustment will then be made incorporating all of the ground control to arrive at the best possible coordinates for subsequent photogrammetric operations.

Aerial Triangulation QA/QC

The quality of the aerotriangulation solution is proven by low values of the error residuals in the least squares adjustment. Very low values in the residuals indicate that the ground control is free of survey errors because it fits the photogrammetric measurements. The quality control steps outlined below will be followed to help ensure the best quality adjustment. The full and complete documentation of the quality control procedures and results will be presented in the Final AT Report.

- The project boundary will be identified to ensure that triangulation coverage includes the entire project area.
- Checkpoints will be used and evaluated as previously discussed above

- Intermediate triangulation results will be thoroughly reviewed by the Lead Technician and the Data Processing Manager.
- Final triangulation results will be thoroughly reviewed by the Lead Technician, Data Processing Manager, and the Manager of Production.

Aerial Triangulation Report

Upon completion of all AT adjustments, Sanborn will submit a Final AT Report in .PDF format, with relevant portions in ASCII format as required by COAGA 2015. This report will provide a narrative description of all aspects of the AT phase, tabular information for ground control and check point results, and appendices, which include documentation of the full AT solution. The Final AT Report will include the following information:

- An executive summary of the aerial triangulation (AT) and its results
- A narrative description of all aspects of the AAAT and AT bundle block adjustments
- A basic description of the project including ground control, flight planning, aerial imagery, and the airborne GPS observations and results
- Equipment and software details
- A description of the AAAT procedures and results including any geodetic considerations such as the use of a Local Rectangular System
- Results of the preliminary check point adjustment, the constrained bundle block adjustment, and the formal classification of the AT in terms of its accuracy
- Raw measured fiducial coordinates for each photo image in the photo coordinate system
- Raw measured control points and pass points in the photo coordinate system
- Adjusted control points, pass points, photo centers and residuals in the NAD 83(2011) SPCS coordinate system with NAVD88 elevations
- Standard deviation of the adjusted control point, pass point measurements, and airborne GPS photo center coordinates
- Photo orientation parameters (X,Y,Z, omega, phi, kappa) for each photo image
- Camera focal lengths used in adjustment
- Documentation of the weighting strategy used for ground control points and airborne GPS coordinates
- Final coordinate listings and other associated data in an EXCEL spreadsheet

Ortho Imagery Processing

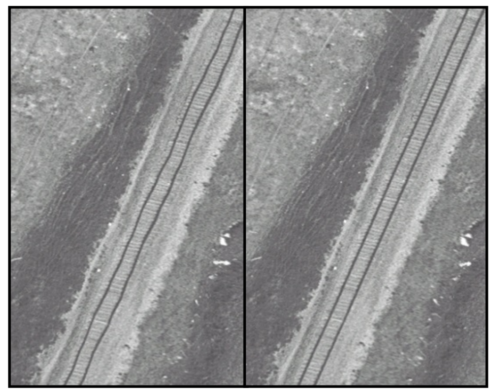
The creation of ortho imagery involves a number of important steps, beginning with the actual orthorectification, which corrects the geometric distortions inherent in digital aerial imagery, and turns it into a true map product. The process also involves mosaicking, and a variety of radiometric corrections, which turn the numerous individual photo images into one seamless database, with uniform, pleasing, realistic color characteristics. After it has been quality-controlled and any needed corrections made, the database is tiled to COAGA 2015's specifications, and written out in the desired compressed or uncompressed image file format(s) for delivery.

- Please note that Sanborn offers delivery of the 4th band (NIR) as an optional product, at no additional costs. Individual members may choose to have their product delivery at either 3-band or 4-band delivery.

DEM Update

The orthorectification process requires a digital elevation model (DEM) as an input. The quality needed depends upon the accuracy and resolution requirements of the project. A DEM that is out of date or of insufficient resolution may cause a variety of geometric inaccuracies in the orthophoto image, including distortion of the image or unsightly, visible smearing. Additionally, bridges, flyovers, and certain other elevated features require special enhancement of the DEM in order to ensure that those features are modeled correctly and the orthorectification is accurate in those areas. Sanborn will update the existing DEM as needed, to properly ortho-rectify the orthoimagery.

Orthorectification



Ortho with DEM *Ortho with TIN*

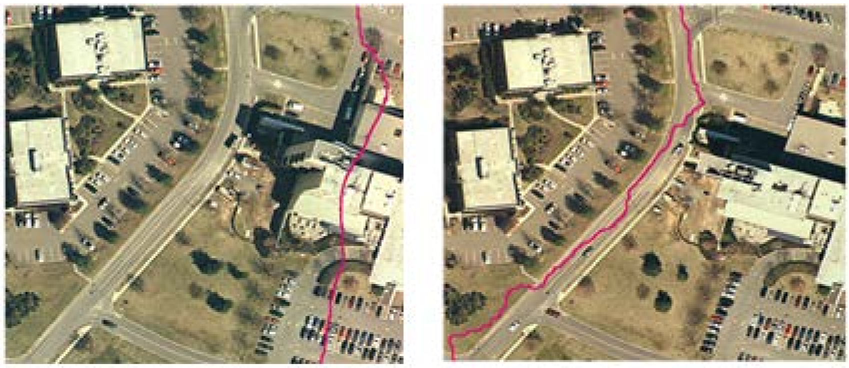
Sanborn uses a highly sophisticated, proprietary software package called METRO (Method for the Elimination of Tilt and Relief Displacement in Orthophotography) for orthophoto creation. METRO is one of the most robust and feature-rich automated digital orthophoto production software suites in the industry. The METRO system draws upon digital elevation/terrain models (DEM/DTMs), digital sensor information, digital aerial imagery acquired for the project, and aerial triangulation (AT) data to rectify each digital image. The rectification corrects for inherent geometric distortions in the image that are caused by terrain variance, earth curvature, and camera orientation in relation to the ground. The terrain surface used by METRO is in the form of a triangulated irregular network (TIN), not a regular grid DEM or DTM. The TIN provides a more accurate representation of the terrain surface. The TIN eliminates waviness around sharp terrain breaks, such as steep embankments, road edges, railway grades, and hydrographic features, as seen by comparing the rail lines in the pictures above.

METRO uses the cubic convolution sampling technique, which yields high accuracy and excellent aesthetic quality. Cubic convolution is the industry standard algorithm for the rectification of digital orthoimagery. It relies on a 4 x 4 (16-pixel) kernel and a cubic algebraic function.

Sanborn has also developed methods and procedures that allow for the processing of the RGB color and near infra-red (NIR) bands within a single rectification. One of the greatest advantages of digital cameras systems is the ability to collect co-registered multi-spectral imagery. Because of this camera design, Sanborn can bring a 4-band image into our software and complete single-step aerial triangulation, orthorectification, and post processing. Prior to this process and the new digital camera technology, imagery providers had to collect RGB and NIR imagery on two separate flights, and perform aerial triangulation and orthorectification twice, doubling the effort, cost, and time to deliver the NIR product. Sanborn believes this new process provides an exceptional value to COAGA 2015, as we will do not charge additional fees for collection, orthorectification, and delivery of the near-infrared data.

Mosaic Processing

Sanborn uses a unique mosaicking process that performs pixel matching along a seam line at ground level. This virtually eliminates image distortions caused by above ground features mosaicked from two adjacent photographs. As part of the mosaicking workflow, experienced imagery technicians review the seams between orthophotos to ensure that adjacent images edge match correctly. The METRO seaming routine avoids elevated structures so that buildings are viewed from only one source image.



Orthophoto mosaic without intelligent seams (left) and with intelligent seams (right).

Seamline Generation

Sanborn's production process allows for seamline generation and a seamline deliverable, if desired by COAGA 2015. This is a product that has been delivered to other clients for many years, and is useful to have when performing quality control on the imagery. The following illustration displays how image chips are used to make a larger mosaic. Each color within this sample represents image chips that are mosaicked together to make a single homogeneous image.

One imagery tile with eighteen contributing exposures

Sanborn tracks each image throughout the production process for the metadata requirements. This same information will be applied to the attribution of the seamline database.

Sanborn proposes to provide project-wide seamline polygons as a vector layer in Esri Geodatabase format. The polygons will be topologically correct, containing no gaps, overlaps or multi-part features, and will contain a polygon for each exposure chip used in the mosaicked image. The polygons will be attributed with exposure identification, and image acquisition date and time.

Radiometric Balancing

Sanborn's image quality criteria require radiometrically homogeneous imagery that is devoid of response gradients and vignetting within an exposure, and unnatural tonal variations across exposures. A four-step radiometric calibration and processing workflow is followed to ensure that these criteria are met:

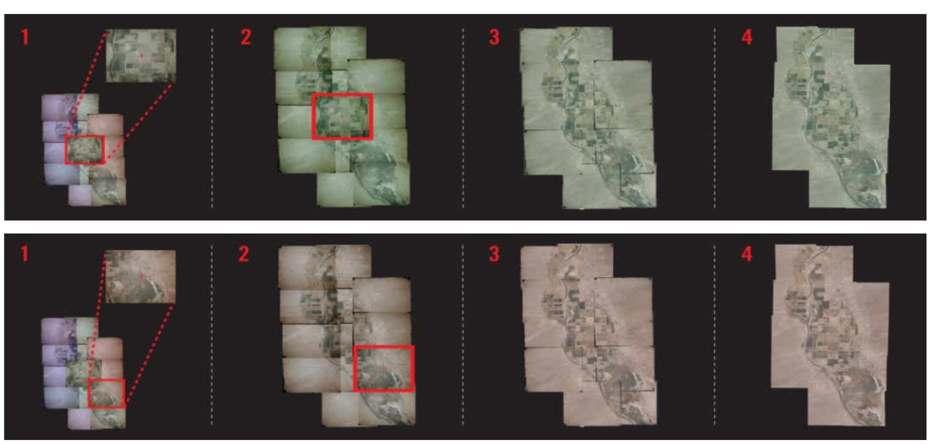
1. **Pre-Flight Calibration:** Camera response is calibrated the day of acquisition for the ground reflectance and expected illumination conditions. The calibration process ensures maximum use of the available 14-bit dynamic range and correct color balance.
2. **Atmospheric Correction:** Atmospheric correction to remove any haze or atmospheric transmission loss using a Modtran4 derived correction function.
3. **Sensor Corrections**: Pre-processing to remove any vignetting effects, resulting in a homogeneously exposed image.
4. **Color Balancing**: Final processing includes local and global color balancing to ensure that all image exposures appear consistent, with no tonal variation across seams.

Final Color Balancing

Sanborn will use tone balancing to even bright and dark areas on the imagery that are caused by changing lighting conditions , such as variance in sun angle, over the duration of the imagery acquisition process. Our procedure enables us to compute an average intensity value for each input image, and ensure that the corresponding output image retains the same average intensity, but with corrections for common photographic problems such as vignetting and uneven exposure. Once dodging has been completed, color balancing is continued using a proprietary color balancing tool called SPICE (Sanborn's Proprietary Interactive Color Editor). This sophisticated tool enables technicians to use an intuitive and interactive methodology to specify the radiometric target characteristics of the final product, allowing the user to specify the radiometric properties of the final orthoimagery using a "what you see is what you get" interface, and also to match easily to client specified target characteristics. COAGA 2015 can provide digital imagery samples as a target, and SPICE will match the characteristics of the target image.

A secondary function of SPICE is to automatically adjust artifacts that typically lead to radiometrically non-homogeneous orthoimagery. This process is particularly important in regional areas with high reflectance, such as water. After selecting mosaic boundaries automatically or manually and defining blend types, either by default or individually, the mosaicking process runs in a batch mode. During the process, the final photos are tone balanced for optimal viewing and seamless mosaicking.

The following images show how this process can provide different radiometric values from the same source imagery based on the selection of different color targets. It is this process that will allow Sanborn to auto-match the radiometry of the prototype signature areas provided by COAGA 2015. Sanborn will ingest COAGA 2015's approved prototypes in stage one of this process to produce the final orthoimagery with similar characteristics. Global tone matching and seamless mosaicking will provide consistent image quality output over the entire project area.

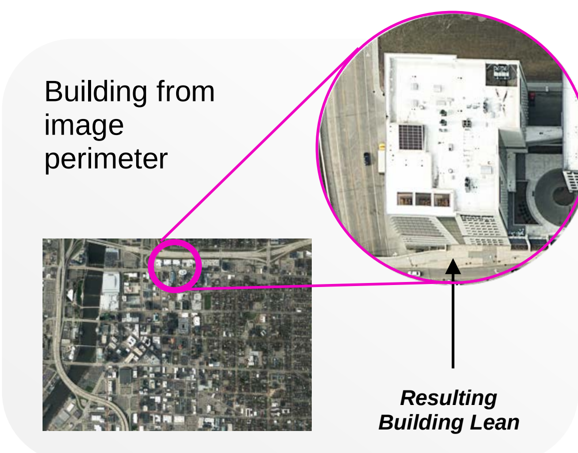


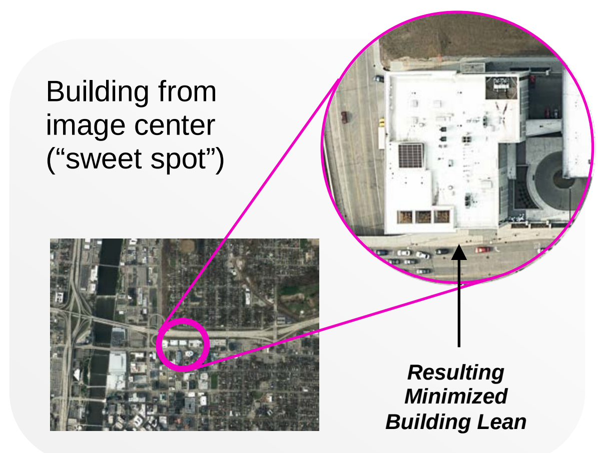
Methods and procedures used in order to ensure a seamless orthoimage database with no discernible differences between adjacent images include:

- Each digital orthophoto will initially be created with a certain amount of overlap between adjoining images. This is necessary for determination of brightness differences between images.
- Pixel groups in adjacent images will be compared to determine the final output values along the seam line.
- Images will be processed so tonal values are consistent across boundaries, with no evidence of a seam.
- All radiometric correction will result in minimally measurable, and visually undetectable radiometric seams within or between flight lines, stereo models, or tiles.
- Sanborn calculates the position of the sun in relation to the camera at the time of exposure. This allows correction for hot spots and reflectance in the photography.
- Radiometric adjustment includes color balancing, overall tone adjustment, and brightness and contrast enhancement of the imagery over the entire project. Client-approved sample data (pilot data set) will be used as reference. There will be no null pixels within tiles.

Radial Distortion (Building Lean) Minimization

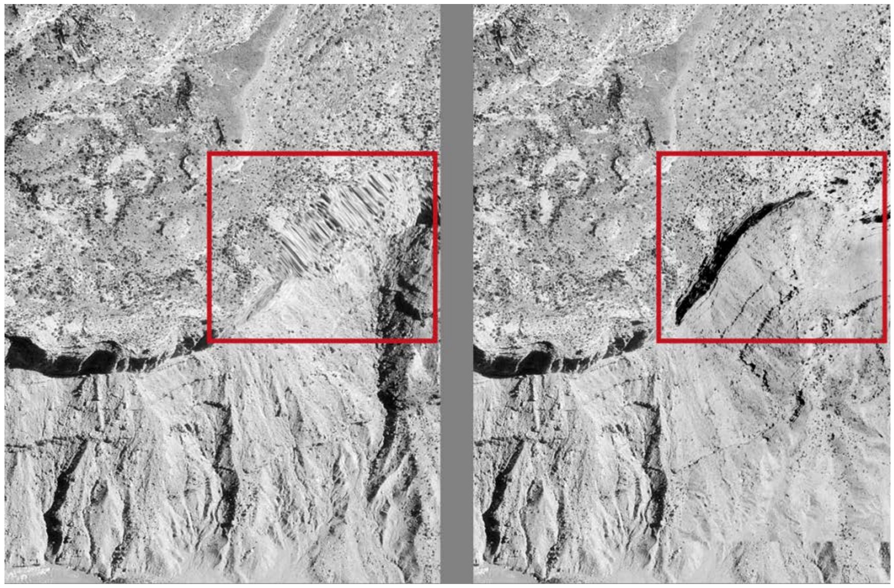
Radial distortion of above-ground features is a common issue with orthoimagery. Sanborn creates orthophotos using only a relatively small inner area, or so-called "sweet spot," from each available image. This minimizes radial displacement and related problems, which increase toward the outer perimeter of a photograph. Using the "sweet spot" also increases the quality of the color balancing between photos. The high-overlap imagery acquired over major urban areas, as well as the higher acquisition altitude capability offered by the UltraCam Eagle sensor will also contribute significantly to the minimization of building lean and other radial distortion.





Smear Correction Due to Terrain

Sanborn utilizes both the "sweet spot" and intelligent seaming to automatically correct for image smears. Image smears typically are found in areas of high relief where the image angle is parallel to the terrain. An accurate digital elevation model is required to correct this problem. As a result of Sanborn's methodology, clients are guaranteed that valleys within high relief areas remain visible. The following image provides an example of image smearing and its correction:



Smeared terrain *Smeared terrain correction*

Correction of Bridges and Other Elevated Highway Features

Distortion of bridges and other elevated highway features occurs when a DTM models the terrain surface, but not elevated features such as bridges crossing over that DTM. Sanborn corrects bridges and elevated highways as a routine step in our orthophoto creation workflow. Sanborn produces a separate DTM for each elevated highway feature, and when used in METRO's rectification process, elevated highway feature displacements will be corrected, with each feature being restored to its true location. Sanborn will deliver a separate bridge DTM file containing all affected bridges and flyovers.

Typical bridge distortion *Following standard Sanborn correction.*

Generation of Final Deliverables

A seamless database of orthorectified imagery will be created and final deliverable tiles "cookie-cut" out of it. This results in deliverable digital orthophoto files that match at a neat line with no overlap or gap. The tiles will be cut to conform to COAGA 2015's tile scheme, and written out in compliance with their desired naming convention. All tiles will be geo-referenced and projected in the specified project coordinate system. A tile index will be provided in Esri Geodatabase format.

All imagery will be delivered at a spatial resolution of X-inches, in .TIFF/.TIFW format. Radiometry will be 3-band, 8-bit per channel RGB/NIR. The database will be delivered on USB External Hard Drives. Please note Sanborn provides the option for each participant to receive the 4th NIR band at **no** additional cost. This band is valuable for a variety of remote sensing applications, such as landcover mapping, storm water mapping, etc.

Additionally, Citywide compressed mosaics in MrSID .SID/.SDW format and JP2000 file formats with 20:1 compression will be provided. Radiometry will be 3-band, 8-bit per channel RGB.

Digital Orthophoto Quality Assurance

The process involved in producing high quality digital orthophotography is dependent upon the successful execution of many tasks performed by several Sanborn departments. While QA/QC is integrated into the workflow, every orthoimage tiles undergoes a thorough visual inspection by experienced imagery technicians following the conclusion of the production process. Any blemishes or artifacts in the imagery will be corrected prior to submittal. Inspections that will be performed on the orthoimagery include, but are not limited to:

- Visual inspection of geometry—Evaluate final geometric fit for compliance to specifications and/or published data quality statistics:
  - Obvious seams
  - Edgematching (roads, buildings)
  - Bridge warping
  - Excessive radial displacement in buildings
- Visual QC of mosaic—Evaluate product quality and modify as needed to meet project specifications:
  - Blurred imagery
  - Inconsistencies of color balancing
  - Artifacts removed
  - Shadow detail
- Product packaging—Final review of product with regard to content, format, labeling

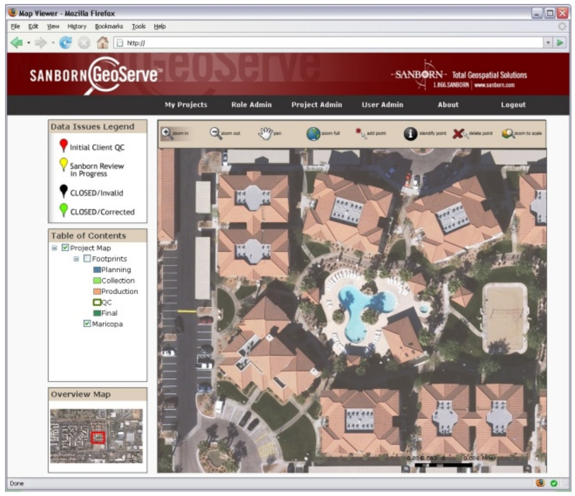
Sanborn understands that imagery which does not meet quality and accuracy requirements will be rejected and will need to be re-submitted following corrective measures.

GeoServe Online Client QC Tool

Sanborn makes an optional service for web-based quality checking of orthoimagery available to its clients. Data is served from a central data server at Sanborn to the customer-side computer and, uses a mapping interface from within a standard web browser.

Sanborn's GeoServe Online QC tool accelerates the review process and expedites final product acceptance. This web-enabled tool removes the need for the physical transport of initial data to the customer site and allows for data to be reviewed and flagged for correction remotely, which reduces the project timeline. Edit flags are stored in a centralized location where they are immediately available for review by others in the organization.

Customer-level login security has been implemented in conjunction with strict firewall functions and policies to help keep unauthorized users from accessing restricted data. Users are able to view available data and add digital issue points to areas which may have perceived problems or errors. These points are submitted directly to a secure centralized database where they are immediately available for others to review. Benefits of this process include:



- Online quality assurance process helps reduce the time needed for review as data can be corrected incrementally with edit calls, often speeding the review schedule.
- Provides ease and standard documentation for data quality review needed for contract monitoring and compliance.
- Facilitates coordination between many data reviewers, even when geographically separated.

Metadata

FGDC-compliant metadata will be provided as part of the project. ArcObjects is used to generate the metadata information in the most efficient manner using semi-automated techniques. At a minimum, the metadata report will contain the following information:

- Date(s) of image collection
- Spatial and spectral resolutions
- Spatial accuracy of image
- Projection and datum of imagery
- Producer contact information for Sanborn
- Orthorectification method descriptions

Sanborn has a staff of programmers who can develop applications as needed to ensure that all expectations for file format and metadata are met. Sanborn will coordinate with CLIENT to ensure that all new metadata is compatible with their existing model. We will customize the attributes as needed to include all relevant information and descriptions and ensure that it meets the Federal Geographic Data Committee (FGDC) standards. Metadata files will be delivered in HTML and .XML format.

LiDAR Option

We understand the mission-critical nature of this project, and the need to ensure that LiDAR map products are acquired and delivered accurately, on budget, and to your specifications. Our goal is to provide high-quality geospatial mapping products that are required for the specified COAGA 2015 participants to continue their mission in disseminating flood hazard information in an efficient, effective, and easily accessible manner. This technical approach outlines our methods and procedures for collecting airborne GPS/IMU controlled LiDAR data, performing GPS surveys and setting of check points, LiDAR point classification, and generation of the derivative data products. We have extensive experience with and are knowledgable in USGS specifications for LiDAR and LiDAR derivative product development.

We understand that hydro-flattened LiDAR is an option for Edmond (with updated HE-DEM and 1-foot contours), Choctaw (with updated HE-DEM and 2-foot contours and Norman (with updated HE-DEM and 1-foot/2-foot contours). All LiDAR and LiDAR products will meet or exceed ASPRS Class 1 specifications.

Sanborn LiDAR Resources

LiDAR technology consists of geodetic GPS positioning, orientation derived from high-accuracy inertial navigation sensors, and a powerful laser operating at 1,064 nanometers in the near-infrared range of the electromagnetic spectrum. The laser sensor head is mounted in an aircraft, and emits rapid pulses of light that are used to determine distances between the aircraft and the terrain below.

The accuracy of the LiDAR technology is sufficient to support mapping accuracy under many guidelines (FEMA, ASPRS, NDEP, USGS, and NSSDA). Point density is a function of the sensor speed, aircraft altitude, aircraft speed, and swath width. These parameters are tailored to suit the requirements of a project.

System calibration and accuracy is verified prior to commencing a collection mission, and a calibration for flight is conducted at the beginning and end of every mission over a calibration range at the base of operations. The test involves comparing the LiDAR data against precisely surveyed edges and surfaces.

Sanborn has invested over $5,000,000 in sensors and processing technology to ensure that our LiDAR capabilities are equal to any in the industry. Sanborn has recently integrated the Leica ALS70-HP sensor, the primary systems we propose to task on COAGA 2015's projects. Sanborn has developed sophisticated processes to integrate multiple sensors into our LiDAR workflow and has standardized our data format to maintain data integrity and accuracies.

Leica AL70-HP Sensor and Hardware

The specifications of the ALS70-HP sensor are as follows:

Description	Leica ALS70-HP
Maximum average radiant power (per channel)	4.0 W (100 kHz - 300 kHz)
Maximum peak radiant energy (per channel)	13 uJ (at 300 kHz)

Description	Leica ALS70-HP
Pulse duration	4 ns (100 kHz - 300 kHz)
Pulse repetition frequency, PRF	20 kHz...300 kHz
Wavelength	1064 nm (INVISIBLE)
Beam divergence (full angle at 1/e)	0.15 mrad
Waist diameter (at 1/e)	6mm
Waist location	at exit window
Nominal Ocular Hazard Distance (NOHD), Scanning at 20 kHz at 300 kHz	159m / 522 ft
Extended Nominal Ocular Hazard Distance (E-NOHD), Scanning at 20 kHz at 300 kHz	1441m / 4728 ft

Flight Planning

Sanborn will carefully plan all missions to ensure that resulting data will be compliant with the requirements set for the project, and review our proposed flight and ground control plans with COAGA 2015 prior to mobilizing any field or airborne resources. Proposed plans will be provided to COAGA 2015 at least two weeks prior to mobilization.

Sanborn will ensure that all mission plans will result in the collection of data that meets the requirements of the specific task order. Mission and mobilization planning will follow the following workflow of key procedures and considerations:

- Sanborn will prepare a digital flight line layout using Track'Air software.
- Sanborn's flight plan will contain the following information:
  - Projected flight lines
  - Flight line numbers
  - Intended coverage
  - Flight altitude
- Sanborn will overlay the flight line layout over Google Earth imagery, and determine optimum locations for the placement of ground checkpoints and GPS base stations, where these items are needed and will be provided to COAGA 2015 for approval.

Sanborn will perform mobilization planning to ensure that airborne data acquisition can progress in accordance with the project schedule. This will include:

- Monitoring conditions within the AOI's to determine when acceptable leaf conditions of deciduous trees, and the conditions of streams and rivers exist.
- Monitoring weather conditions
- Ensuring that missions will be flown when the PDOP is less than 3.2 and the KP index is less than 4.

- Locating airports at which to stage aircraft and aircrews, and arranging for their accommodations.
- Making arrangements to access restricted airspace

Flight Planning Parameters	
Max AGL	3500m
Max Measurement Rate	500kHz
Max FOV	0-75° (Sanborn's Max FOV: 55°
Max Scan Rate	200Hz @
Scan patterns	sine, triangle, raster
Number of intensity Measurements	3 (first, second, third)

LiDAR Data Acquisition

Sanborn follows a number of key guidelines in order to minimize errors resulting from GPS ground station, Airborne GPS, IMU, and LiDAR operations. GPS data is collected using survey-grade receivers and antennas. Positional Dilution of Precision (PDOP) and satellite availability is forecast using GPS planning software. Missions will not be collected when the PDOP value exceeds 3.2, and the satellite availability is under 6. In addition, the KP index is accounted for, which forecasts geomagnetic activity at the earth's surface as a result of solar activity. Collection will not occur when the KP index exceeds 4.

The GPS parameters are followed for both the airborne GPS and ground reference GPS collections. In addition, five- to ten-minute static collections are done at the beginning and end of each flight to increase the positional accuracy of the GPS data. Also, baselines are limited to an average of 20km to any ground base stations in most cases, but will not extend past 30km for a high-density collection. Field QC processing will be done on all GPS data to verify a combined separation of both the forward and reverse solutions to yield a 10cm difference, helping to ensure the integrity of the GPS data.

Sanborn's IMU collection process employs both internal and manufacturer-recommended procedures to ensure reliable data collection. The IMU is initialized on the ground, pre-flight, and will be in fine alignment prior to taxiing the aircraft. Procedural S-turns will be conducted prior to collection of LiDAR data to further orient the IMU. The collection of data in a straight line will not exceed 20 minutes, because the IMU tends to drift after this time. During collection, the flight-line will be flown in a back and forth pattern based upon adjacent flight lines, and never in a "race track" pattern, in order to limit IMU drifts. This collection process emulates elongated S-turns, ensuring that the IMU continues to correct itself. The IMU data is processed during the field QC process for every flight, and verified to ensure a tolerance using the manufacturer's processing software. A series of graphs are checked to verify the data as recommended internally and by the manufacturer.

Atmospheric conditions prior, during, and after the flight are recorded to account for any atmospheric refraction that might occur during collection. These values are entered into the processing software to account for any refraction. Extensive research has been done pertaining to this source of error. As a result, standard models have been developed based on region. Sanborn's Leica ALS-70-HP LiDAR system has the ability to utilize these values, and they are recorded for every mission flown.

Sanborn employs rigorous QC processes in the field to ensure data integrity and to limit error sources. The data must pass the field QC process to be accepted. In addition, Sanborn has instituted additional processing, QC/QA procedures, and checklists in the controlled LiDAR processing environment to further refine the quality of the data.

Weather and Timing Considerations

Sanborn will monitor weather and atmospheric conditions, and will not conduct LiDAR missions when conditions below the aircraft/sensor will negatively affect the collection of data. These conditions include rain, virga, fog, smoke, mist and low clouds. LiDAR systems are active sensors, not requiring light, thus missions may be conducted during night hours when weather tends to be more favorable, and potential ATC conflicts and airspace access issues minimized.

Upon issuance of a task order, our data acquisition department begins monitoring weather conditions in conjunction with the acquisition schedule, using a variety of online weather reporting and forecasting resources. In addition to those websites, Sanborn has online access to more than 3,000 weather cameras located throughout the United States, enabling us to more accurately assess current conditions near the project site.

Four to five days prior to the planned day(s) of acquisition, the Sanborn project team begins to monitor the weather more closely, checking all sources for forecasts at least twice daily. When weather conditions look conducive for acquisition, the aircraft mobilize to the project site. Once on site, the acquisition team takes responsibility for weather analysis. During the collection phase, Sanborn will keep COAGA 2015 abreast of our progress, as well as any interruptions due to unfavorable weather conditions.

Sanborn has derived from manufacturer's operating specifications and our LiDAR operations history a set of flight mission weather parameters that we will not exceed in order to optimize reliable LiDAR data collection. These parameters include:

- Atmospheric and safety considerations, including relative humidity, clouds and haze conditions.
- If optimal conditions exist at night, operations can be conducted then as well.
- If smoke exists in the collection area, missions will not be flown.
- We will not collect data in moderate to severe turbulence, or with a cross wind of 25 knots or more.
- Aircraft crab angle will not exceed 25 degrees at any time.
- If dew point exceeds or is within two degrees of relative temperature, then no data collection will be performed.
- If any rain or standing water exists in the collection area, then data collection will be postponed.
- No unusual flooding, water inundation, or snow, unless directed and approved by COAGA 2015.

Global Positioning System Control

Sanborn's GPS control process will use CORS and existing control whenever possible. Two ground base stations will also be set up by Sanborn for a 0.5 second epoch collection rate during every mission for the duration of the mission. In the event that more than one mission is conducted on the same day, GPS base station collection will run in excess of both flight missions. A base station network will be established to incorporate no less than two COAGA 2015 survey points, or if unavailable, the following combination associated with the points: two published horizontal orders of HARN quality, and two published vertical orders of first Class II. If necessary, the network will be expanded to accommodate the minimum requirements for the network.

Additional GPS ground points may be required to be set, established, and surveyed to the network to accommodate baseline distance requirements for the project. Typically, a combination of two of these points will be occupied during collection missions, and durations will average three to four hours depending upon baseline distance to the project extents. In the event that a point is not used for mission collection but is established for the control network, it will be occupied for a minimum of 30 minutes with an additional two minutes for every 1.6Km of distance exceeding twenty miles of distance for the baseline to be surveyed. Minimum occupation of any given point will be 90 minutes for secondary points and an average of four hours for primary points based on this configuration. Baselines will be established for the network over the course of project collection for all points used as ground control. Average baseline distances will be approximately 15km to 20km, and will not exceed 30km for COAGA 2015's projects. The survey network will be established and adjusted using orthometric heights, which account for differences in the Geoid model when establishing ellipsoid heights for processing. Several years of consistent, independent accuracy results have proven this the most accurate process to ensure data integrity and meet the standards set in this proposal.

Acquisition Tracking, Reporting and Quality Control

Sanborn employs rigorous QC processes within 48-72 hours of data collection to ensure that the data acquired meets the requirements of the project. The acquisition and QC status is updated on a daily basis, and the information will be accessible to COAGA 2015 via a GIS-based Web page.

- *Field data verification*: The field crew downloads the data, and ships a duplicate set of the data on portable hard drives via next-day courier delivery to the production office. The field crew then processes the approximate GPS-IMU solution, the decimated flight lines, and views the point cloud to confirm the quality of the data collected. This is accomplished within 24 hours of data collection. Special attention is paid to flight lines where any turbulence/disturbance or sensor-related problems are marked on the flight-logs. The flight plan for the next day is updated on the basis of the lines flagged by the acquisition team during the field data verification process.
- *Office data verification*: The data for each mission arrives in the production office on the day after acquisition. The LiDAR processing team processes the data with precise GPS-IMU solutions and generates the full resolution LAS flight line strips. The team then checks the data carefully for gaps, sensor anomalies, NPS, FOV, side-lap, and other flight-related parameters. Any re-flights needs identified during this QC process are then transmitted back to the acquisition team by the acquisition manager. The office data verification is completed within 24 hours of receiving the LIDAR data in the office.
- *Online flight tracking system:* Sanborn has designed a GIS-based online acquisition system that can be used by the client to track the status of acquisition, data validation, QC, and re-flights on a daily basis. This online system is described in the aerial acquisition section of our response.
- *Reporting to* COAGA 2015 *By 10:00* am each day, Sanborn's project manager will send an e-mail to the State's project manager to indicate whether any LIDAR acquisition was

accomplished during the preceding day. The e-mail will also supply a brief description of the areas captured and/or an explanation for areas where data was not collected. By 5:00 pm, the Sanborn's Project Manager will deliver an updated version of the flight plan shapefile(s) indicating which lines/areas were captured on the preceding day.

LiDAR Post Processing

All data is post-processed in a controlled environment based upon strict procedures designed to maintain data integrity and to provide the best possible data to COAGA 2015. The following is an outline of the data processing work flow completed at Sanborn's office after the field verification and in-field QA/QC processes have been completed.

- LiDAR Calibration (Multiple Calibrations Stages)
- LiDAR Classification
- Final Product Generation
- Creation of Metadata
- Quality Control

LiDAR Calibration Overview

Sanborn conducts possibly the most extensive sensor calibration in the industry. We calibrate all sensors prior to installation, every three months, and during every mission. This enables Sanborn to guarantee the data accuracies required by our clients. Our calibration process is detailed below.

- GPS-IMU Processing
- Installation Calibration
- Mission Calibration
- Final LiDAR Calibration Using TerraMatch
- DZ Ortho process: for relative accuracy
- Check-Point Z Adjustment

Horizontal point accuracy is a function of angular origination of the pulse, IMU orientation, and the scanner encoder and ranging function. These will vary depending on the proposed point density selected for the collection. Statistically, the error is roughly one-third of the illuminated foot print on the ground and is a function of the beam divergences. It is also affected by the reflective nature of the surface at which it strikes.

The biggest factor in vertical accuracy is GPS data quality, but it also can be affected by laser range function, IMU orientation, and scan angle. There is a higher percentage of range ambiguity at higher repetition rates. This is further dependent on the distance between returns. Sanborn accounts for this by adjusting the repetition rate of the laser based on collection parameters and desired point sample densities. In addition, during the processing of the LiDAR, the flight line swath data is trimmed to cut off excess errors at the FOV edge. Sanborn will ensure that the calibrated LiDAR dataset meets or exceeds the specifications of the project.

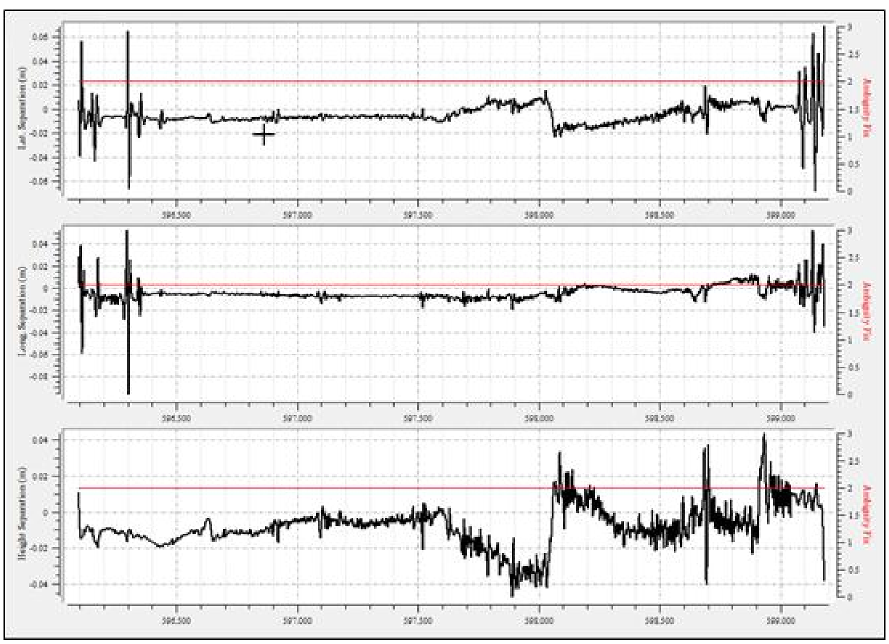
GPS-IMU Processing

The differential kinematic data are processed together with a minimum of two static base stations and the solutions are compared. This procedure verifies the integrity of the base-station coordinates and elevations. Each processing session is computed in both forward and reverse temporal directions. The comparison of these solutions provides insight into the quality of the kinematic ambiguity resolution.

During the mission planning process, Positional Dilution of Precision (PDOP) is considered through vendor planning software packages. Sanborn uses Trimble's Qplan and Ashtech's MPwin GPS planning software. All mission collections will be conducted with a PDOP of 3.2 or lower. The KP index is also considered prior to mission collection. KP index is a measurement of geomagnetic activity at the earth's surface that can greatly affect the GPS solution. Therefore, no collection will occur when the KP index is at or above 4.

Airborne and ground GPS data are collected at half-second epochs for the duration of all missions. In addition, five-minute fixed static surveys are collected at the start and end of all missions. This step insures the airborne GPS unit is functioning properly and the solution is fixed.

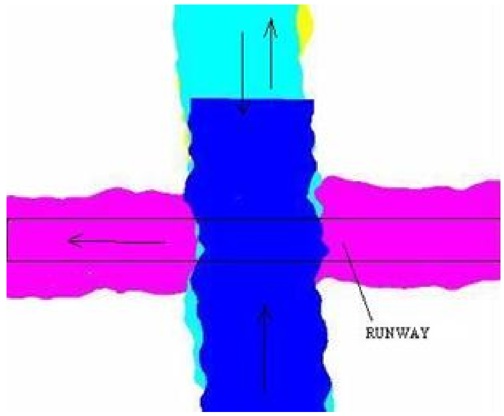
There are several considerations to be taken into account during the actual processing of the GPS data. Parameters such as satellite health, cycle-slip tolerance, satellite elevation mask, kinematic ambiguity resolution, ionospheric correction, L1/L2 carrier phase, and base station information will be refined to yield the best possible GPS solution. In addition, several QC/QA checks are done within the software to ensure a best fit solution. The following figure illustrates a suitable combined solution, predominantly within 4cm.



Combined Solution Example

Installation Calibration

Sanborn conducts extensive calibration and GPS lever arm surveys for all sensors and aircraft installations. The GPS antenna in the aircraft and its reference to the LiDAR sensor head are surveyed using a Leica total station. Several reference points on the aircraft and sensor are measured to validate the location of the sensor GPS antenna in relation to the sensor head. These reference points include the tail, nose, antenna, sensor reference location, and point below sensor scanner on the ground. This process consistently yields GPS lever arm offsets (x,y,z) locations within two millimeters or less.



Sanborn has established calibration test ranges at the Colorado Springs Airport and downtown Colorado Springs for calibration of the LiDAR sensors. Every LiDAR sensor is calibrated after every installation into an aircraft. Recently, Sanborn has instituted an additional calibration dataset for better calibration. Sanborn has surveyed in the downtown calibration with our Lynx Mobile Mapping unit. This system operates two 200 kHz lasers on a mobile platform. This system is capable of achieving two-centimeter accuracy and a LiDAR point density far more dense than an airborne LiDAR sensor. This sensor is used to validate and correct for both vertical and horizontal accuracy of the airborne sensors. Results have improved the relative and absolute accuracy of our airborne sensors.

Providing a stable platform of all Sanborn sensors is critical for project success so the removal and installation of sensors from Sanborn aircraft seldom occurs. As a result, Sanborn has instituted a routine calibration schedule of every three months for every LiDAR sensor.

Calibration missions are conducted over a surveyed runway surface and a series of surveyed buildings at three different altitudes: 800 meters, 1,500 meters, and 2,500 meters for the Leica MPia systems. A series of flight lines over the calibration test site are flown in both parallel and perpendicular flight lines at each altitude. In addition, for the Leica MPia system, the system is run in bit mode on the ground to assess the relationship of four returns in Bank A in single pulse mode and the relationship of the four returns in Bank A and Bank B for the multi-pulse mode. The image above represents a calibration run at one altitude and indicates three opposing flight lines perpendicular to the runway and one flight line parallel over the runway. The runway is surveyed using kinematic survey procedures during every calibration. Static GPS validation surveys are conducted to verify the kinematic reference survey.

The goal of the calibration missions is to determine any necessary software adjustments for the hardware to ensure the highest relative and absolute accuracy achievable. Measurements for roll, pitch, yaw, torsion, pitch error slope, Z–Bias, and range correction are checked, calculated, and determined. Other variables like relative accuracy between flight lines, scan factors, and intensity table values are checked and changed if necessary. Given that Sanborn's sensors remain stable once in an aircraft platform, it is often not necessary to change these parameters, but it is imperative to validate them routinely. In addition, several tests are done on the IMU and GPS systems to validate proper operation and accuracy. It is imperative to continually check these sensors and make necessary changes as required.

LiDAR Mission Calibration

In addition to the process Sanborn conducts at installation and every three months, Sanborn performs an abbreviated version of the installation calibration process for every LiDAR mission. At every project base of operation, the runway is kinematically surveyed by making three passes down the runway. One pass is down the middle of the runway and two are down the edges of the runway, providing an average of 3000 to 4000 points along the runway. The vertical accuracy will be no less than 3 cm (1 sigma). Elevation points will be sufficiently dense to adequately represent the surface to the required accuracy. The test surface will be approximately 70 meters wide and 500 meters long.

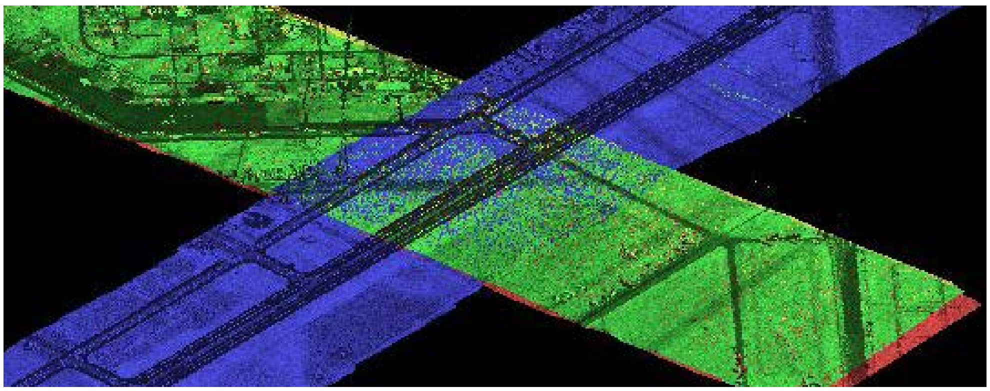
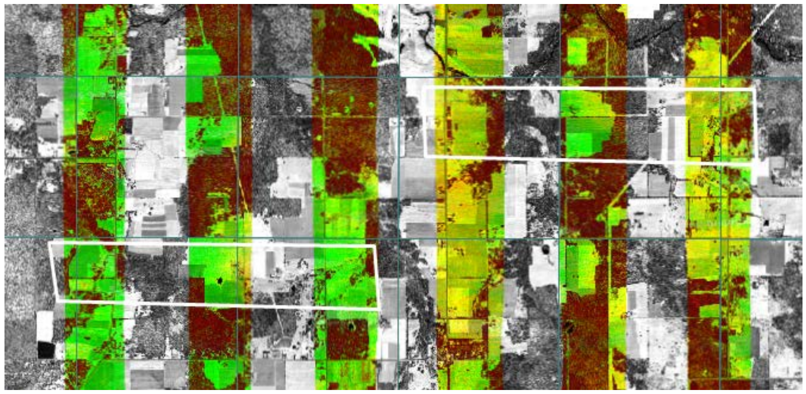


Illustration of four different calibration strips on runway TerraMatch finds and corrects errors automatically creating an initially accurate dataset.

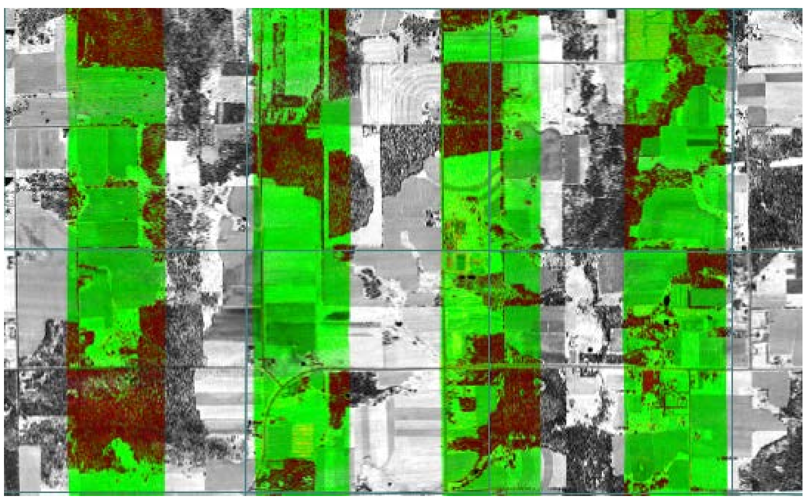
Prior to project area collection, two passes perpendicular to the runway in opposing directions are flown. At the end of every mission collection, two additional passes over the runway are flown. One pass is parallel to the runway to detect edge of scan differences in relationship to the runway and other calibration lines. The final line is flown perpendicular to the runway to check the swath repeatability from the beginning to the end of the flight. In addition, a cross flight is flown in all project areas to check flight line repeatability within the project area. The mission calibration is done to verify all the parameters mentioned in the installation calibration section and the graphic in that section is representative of the mission calibration. In addition, the system is run in bit mode for every mission to further valid and adjust the relative relationship of the return as they relate to single pulse or multi-pulse, and Bank A and Bank B. This process ensures both relative and absolute accuracy.

Final LiDAR Calibration Using TerraMatch

Sanborn uses many different calibration techniques to ensure the client is getting the most accurate data possible. By implementing the use of TerraMatch, a product from TerraSolid, the dataset can be corrected for systematic biases. These adjustments are almost completely automated, and assist in the accuracy against the surveyed control points. TerraMatch further improves roll, pitch, heading, and torsion between each mission to form a dataset that is precise, and well within the client-defined accuracy specifications. By placing sample tiles perpendicular to the direction of flight, TerraMatch analyzes each swath simultaneously. A file is then output containing each swath's corrections. This correction file is then applied to the entire project and/or block.



Swath to swath systematic errors are shown. TerraMatch uses the sample tiles to find biases between swaths and correct for them.



Swath to swath errors are corrected automatically by applying correction file.

Dz Ortho Imagery Process

Sanborn uses Dz Ortho images to analyze the calibration. These images are specific to LiDAR processing, and quickly show any potential calibration issues. Dz Ortho's are recreated between the initial runway calibration and again after the TerraMatch step. The coloring of the images indicates degree of offsets between each swath in four intervals, ranging from green to red. Image settings are as follows:

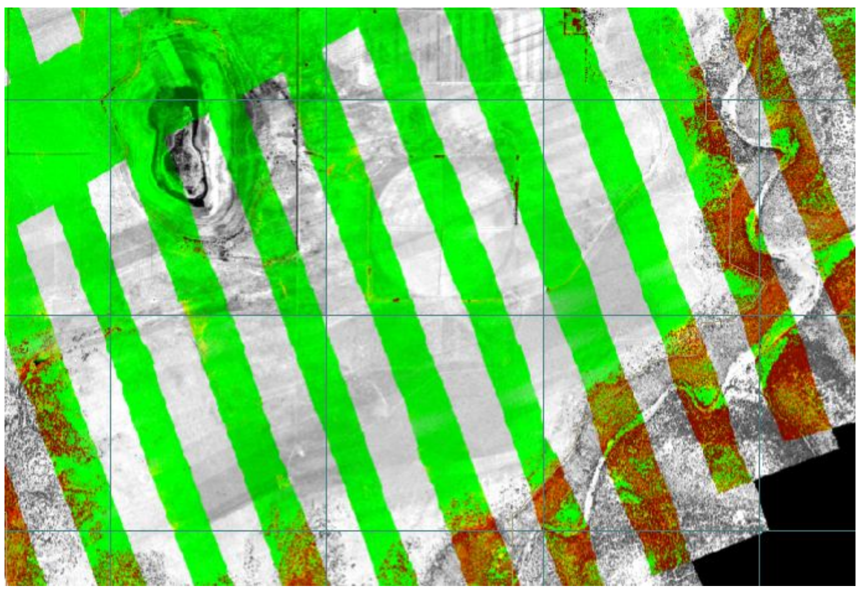
- Green: 0-7cm offset
- Yellow: 7.1-14cm offset
- Orange: 14.1-21cm offset
- Red: >21.1cm offset

These images are efficient and easily viewed, and the LiDAR team at Sanborn manually analyzes the actual data to ensure data quality. Bare earth should always show as green from swath to swath. Vegetation is usually shown as orange or red. After all TerraMatch corrections are applied, the dataset is filtered and manually edited for anomalies to provide a clean, artifact-free bare earth dataset.

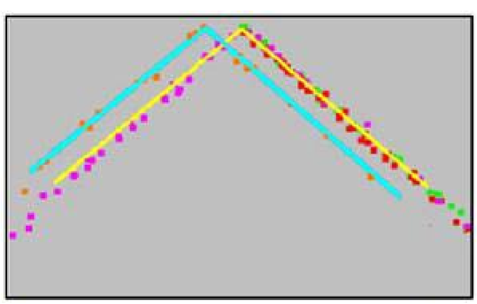
Check Point Z Adjustment

Sanborn collects multiple survey control points for each project area to accurately adjust data Z. Once the data has been through the editing process, the bare earth from the LiDAR data is compared to the processed survey points. In order to achieve the lowest RMSE, the data is adjusted to the Average Dz. This is the mean of all points and their offset to the LiDAR. Once the LiDAR is vertically adjusted, it's ready for product generation.

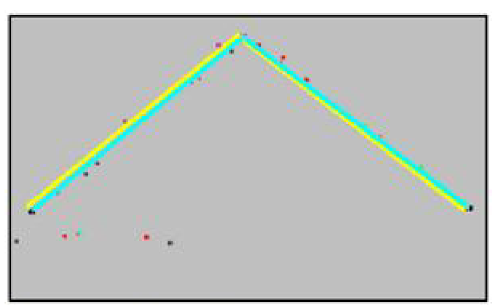
Minimum errors, the range, the mean, the Root Mean Square Error (RMSE), and the standard deviation are calculated for every mission. This will be provided to COAGA 2015 in the final LiDAR project report.



Final calibrated dataset showing swath to swath edge match coloring. Dz coloring indicates degree of offsets between each swath.



Laser points on a building roof show mismatch different flight lines



Laser points after matching process

Profile view of two mission strips. Smoothing, blending or normalizing of the vertical measurements.

LiDAR Classification

Once the calibration of the data is completed, the project moves into the next most important stage of LiDAR production, classification of point cloud.

LAS Classification Options	
Code 1	Processed, but unclassified
Code 2	Bare-earth ground
Code 7	Noise (low or high, manually identified, if needed)
Code 9	Water
Code 10	Ignored Ground (Breakline Proximity)
Code 11	Withheld
Code 17	Overlap, unclassified
Code 18	Overlap, ground
Code 23	Overlap, low point and noise
Code 24	Overlap, water

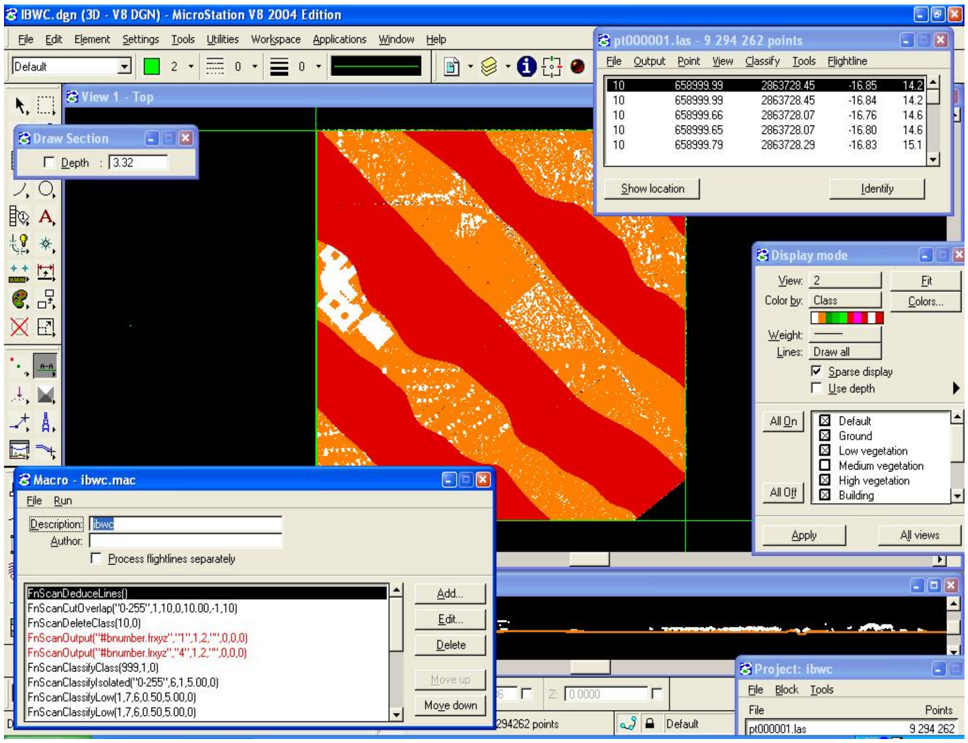
Automated and manual classification accuracy will produce data that meets the following criteria. Sanborn will ensure that the point classification will be consistent across the entire project and there are no noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions exist in the data. Sanborn will make sure that within any 1km x 1km area, not more than 2% of the points will possess a demonstrably erroneous classification value.

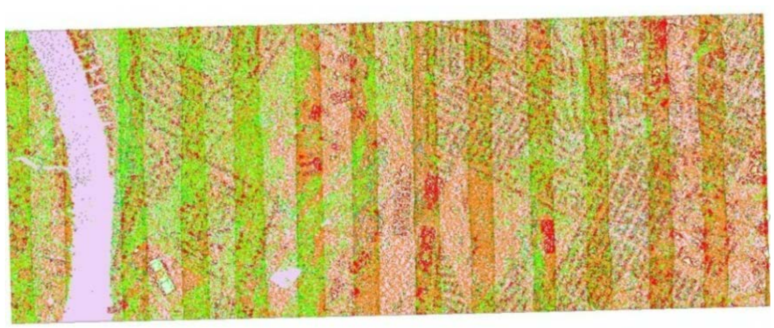
The point classification is divided into the following steps:

- Automated Macro Filtering
- Manual QC and editing of the classification
- Final classification QC using the Hillshade surface

Automated Macro Filtering

The initial LiDAR point cloud classification is done using the automated Terra-Scan macros. The macros are designed to classify the points to the classes required for the project. Sanborn uses a variety of commercial and proprietary software to build macros for automated classification. The macros are specific for each type of geography within a project, taking into consideration terrain relief, ground cover, natural and man-made features. The macros exploit the information related to the number of returns of a pulse, elevation, slope, and height from ground and other terrain characteristics to classify the point cloud in an automated fashion. The routines will classify points based upon the laser attributes including intensity, elevation and the numeric value of the return.





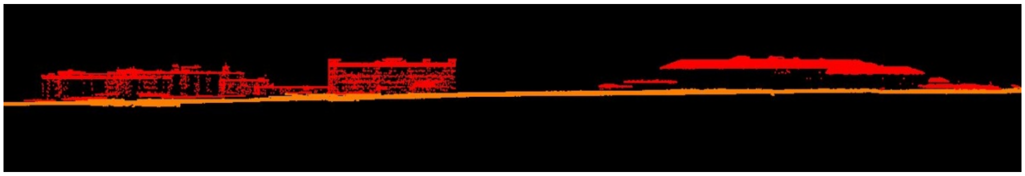
This image shows each of the classifications: Unclassified, Bare Earth, Low, Medium, and High Vegetation, Buildings, Water, and Overlap (withheld, swath overlap).

Manual QC and Editing of the Classification

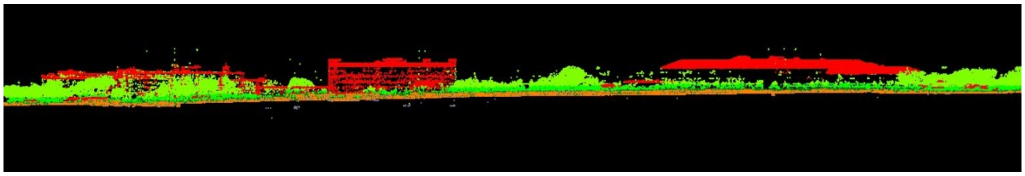
Following the automated classification process, a supervised or manual classification is performed. Sanborn's software can handle an unlimited number of different surfaces in the same digital file. Sanborn's LiDAR editing team goes through the tiles with great precision to make sure that the points are classified correctly. 3D tools include cross-section or profile views of points to aid in classification, surface model visualization with rapid contour development to spot bare earth blunders for re-classification. Color triangles display of TINs, colored grids for shaded relief and other sophisticated visualization tools support the manual classification. The KML file of the project area is made available to the editors so that in case of any confusion in feature identification, they can verify the feature in the imagery and classify the points in the right class accordingly.

KML file of tile boundaries shows features and extents to aid in manual classifications.

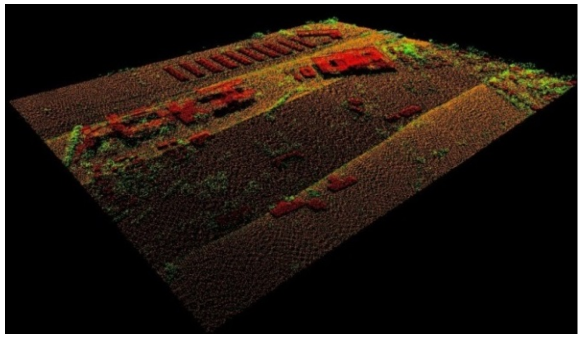
The following are classification examples produced by Sanborn:



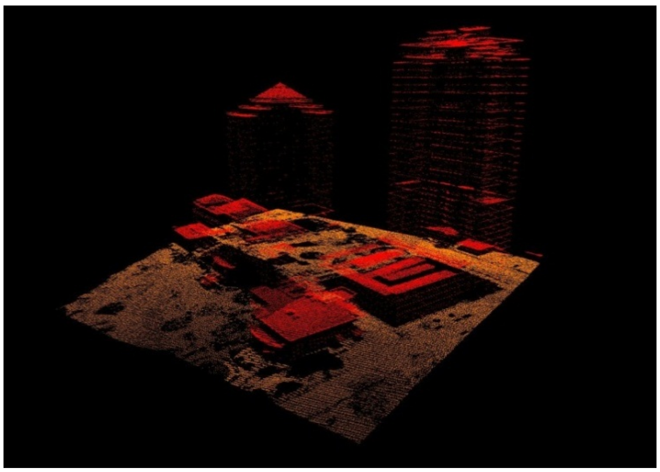
Profile (side) view of bare earth and building structures



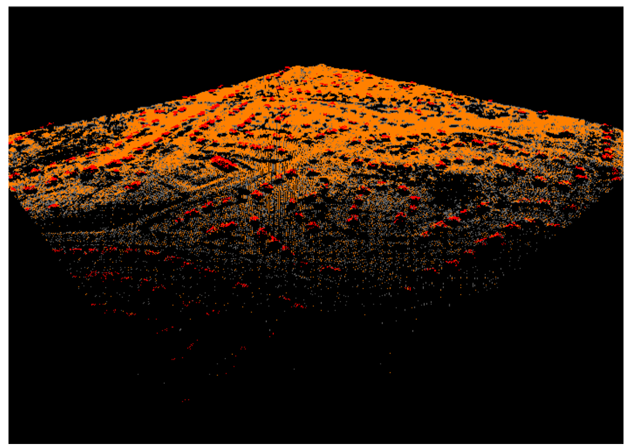
Profile view with vegetation classified from low, medium, to high



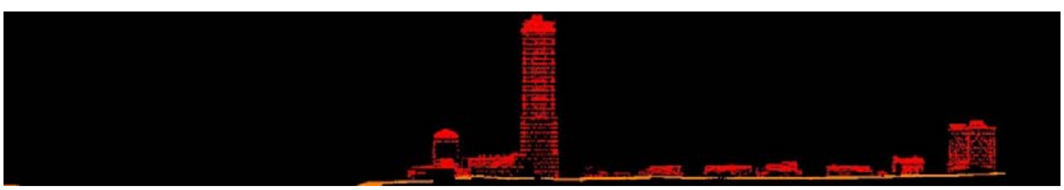
Isometric view of classified LiDAR points



High density LiDAR used to map taller buildings.



Isometric view of urban district with buildings and bare earth.

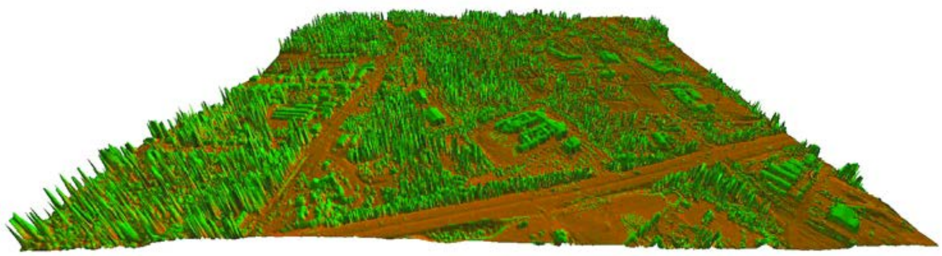


Profile view containing taller buildings.

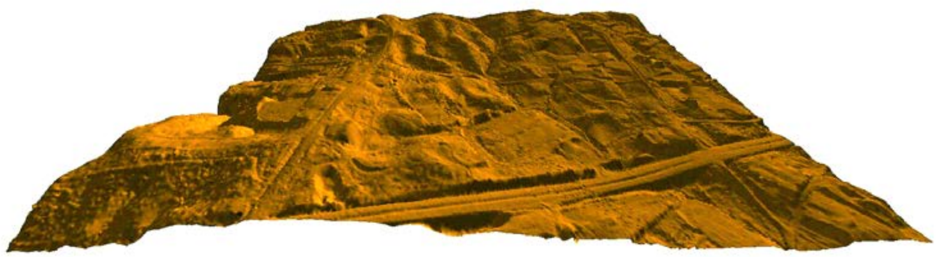
Final classification QC using the Hillshade surface

Part of Sanborn's QC process is eliminating need for extensive manual editing, and replacing this with an automated way to quickly depict outliers or anomalies in a bare earth dataset. Through the production of hillshaded surfaces, Sanborn's LiDAR team can scroll through hillshades (TIF images) generated from the bare earth. This means quicker file load times and the ability to find errors in the bare earth without manually opening each individual LiDAR tile. The team member can also import these hillshades into Google Earth to provide an even better perspective on the terrain. Hillshades are created automatically and quickly, providing an even more efficient streamline editing process.

Shows Hillshade import before and after in Google Earth.



Surface with Non-Terrain Artifacts (green)



Surface with Classified DTM

Hydro-Flattening

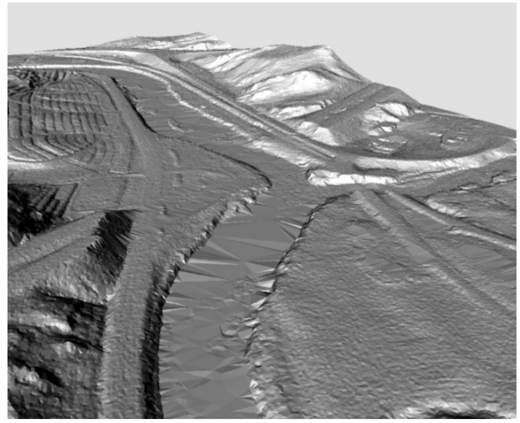
Hydro-Flattening Breakline Development

Sanborn digitizes hydrology features and edge-of-water breaklines using stereo-intensity images into a 3D dataset. Planimetric mapping includes all hydrology and select man-made features, such as bridges and dams that affect hydrological flow. During this phase, each tile is viewed in both 2D and 3D perspectives as intensity images, shaded relief maps and/or digital surface models (DSM). Sanborn populates the "Z" value for the points, lines, and polygons referencing the bare-earth LiDAR. Each hydrology feature is digitized in true horizontal position, and the Feature Type and Class are captured along with the X, Y, and Z attributes. Once all of the features have been captured, a second technician performs a review for content and accuracy referencing the collected features to the base LiDAR data and reference imagery before releasing the tile for final edit.

If desired, Sanborn will produce hydro-enforcement/hydro-flattening to the following parameters.

Sanborn will collect **lakes** and **ponds** as follows:

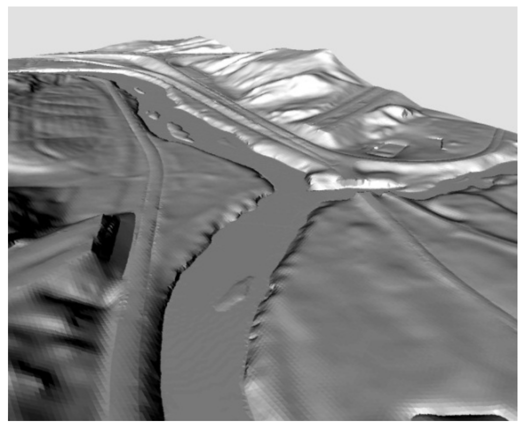
- Water bodies (ponds, lakes, reservoirs) greater than ¼ acre in size.
- Flat and level water bodies (single elevation for every bank vertex defining a given water body).
- The entire water surface edge must be at or below the immediately surrounding terrain.
- Long impoundments such as reservoirs or inlets, whose water surface elevations drop when moving downstream, are required to be treated as rivers.



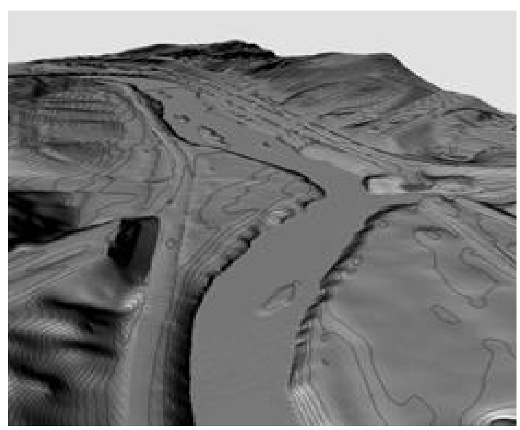
LiDAR surface before breaklines

Sanborn will collect **rivers** and **streams** as follows:

- Double breaklines will be digitized for streams and drainage ditches more than 2-meter wide
- Drainage ditches will be a single line if less than 2-meters wide
- Flat and level bank-to-bank (perpendicular to the apparent flow centerline); gradient will follow the immediately surrounding terrain. In cases of sharp turns of rapidly moving water, where the natural water surface is notably not level bank-to-bank, it is appropriate to represent the water surface as it exists in nature, while maintaining an aesthetic cartographic appearance.
- The entire water surface edge will be at or below the immediately surrounding terrain.
- Bridges will be removed from the DTM. Streams and rivers will be continuous at bridge locations. Bridges will be defined as having an elevated deck structure that does not rest on earth.
- When the identification of a structure such as a bridge or culvert cannot be made reliably, the feature will be regarded as a culvert.



LiDAR surface after breakline enforcement and hydroflattening



LiDAR DTM surface showing smoothed contours

Sanborn's final processing includes the use of custom routines to validate flow direction and monotonicity to ensure all vector nodes are flowing downhill for single- and double-line streams, or are the same elevation for pools of water, including lakes and ponds. Other processing may include using standard Esri tools to eliminate pseudo-nodes that would impair hydrologic analysis. These added-value processing techniques provide a gateway for the datasets to be used for redefining and providing better resolution and accuracy for watershed, lake shed, and boundaries definition.

Contour Production

The LiDAR and breakline DTM will be processed to generate contours. The area of input data will extend somewhat beyond the intended limits of the contouring. This larger-sized area is used so that when the TIN (triangulated irregular network) is created, it extends past the edge of the deliverable area. This is necessary to ensure that proper interpolation of the contours takes place throughout the area being mapped. Once the contours have been created, they are trimmed back to the intended mapping limits.

Since the same set of masspoints and breaklines are used to create the TIN for adjoining map areas, edgematching errors along the area seams are held to a minimum. Sanborn's proprietary processing software will automatically flag all mismatched contours so that a graphic technician can correct any problems. Smoothing and filtering routines will be used to ensure that contours have a pleasing cartographic experience, while still maintaining geometric accuracy and optimizing the size of the contour database by eliminating redundant vertices in the contour strings.

Sanborn has provided cost for delivering both original and smoothed contour lines.

Contour data will meet the following specifications:

- All index contours will be clearly distinguishable and labeled with the their elevations given in full feet;
- Every fifth contour will be an index contour and should be clearly distinguishable as such;
- The elevation of the contour will be easily discernible;
- Contours will be continuous
- Data will be layered in compliance with the agreed-upon database design, including all symbols, colors, and linestyles.

Contour QA/QC

Sanborn has developed a thorough quality control process to ensure the quality and integrity of all of the topographic data products it produces. Special care is taken to precisely define all requirements for the data to be created, and stringent quality control measures are put in place to ensure that all data meet those defined requirements.

When they compile DTM data for contour generation, Sanborn's photogrammetric technicians view DTM points (masspoints and breaklines) draped over a stereo image in a 3D softcopy environment, and position individual points or groups of points at positions to correctly model the terrain surface. Operators will generate contours "on-the-fly" at various stages of the stereocompilation editing process to ensure that any final, generated contours will be "on the ground" and within accuracy specifications.

Although normal quality control checks, such as data overlay and aesthetic control are performed iteratively for all datasets, Sanborn has also developed a series of automated software checks. These checks are performed each time a data file is processed, or when data is graphically edited. Having these automated checks in place ensures that all errors are discovered during the production process. Specific routines are used within the processing environment to ensure that connectivity of linework is complete and specific layers of line topology are generated, so that line features are free from dangles, overshoots, and undershoots. Sanborn will also ensure that data features meet all topology requirements when the data is placed into the target environment.

Checking for process area edge mismatches is a standard part of all Sanborn projects. Using an automated process, each area is checked against its neighboring areas to ensure that all contours match. After the process completes, a graphics technician digitally reviews each area and corrects any mismatches in line placement or attribution that were flagged by the edgematch routine. This process is repeated until no errors are flagged.

LiDAR Quality Control

Sanborn uses a quality-review process for all data to ensure adherence to product specifications, data formats, and data completeness for all deliverables. All data is post-processed in a controlled environment based on strict ISO 9001:2008 compliant procedures designed to maintain data integrity through highly standardized and controlled procedures for data acquisition, post-processing, and validation. The following table provides an outline of Sanborn quality assurance and control procedures for a LiDAR project:

QC Checklist		Methodology	Contractual Requirements	Department Lead Sign-off
PRE-ACQUISITION REVIEW: These checks are to make sure flight planning is done according to the contractual requirements.	Project Boundaries	Confirmed with the client by the PM and released to the acquisition after sign-off		
	Flight plan	Checked by acquisition manager and Submitted to client for review		
	Sensor Settings	Checked and verified by the acquisition manager		
	Weather conditions	Verified by the operator		
	Survey Plan	Checked and verified by the geomatics engineer		
	Base-station location	Verified by the geomatics engineer against the contractual requirements for the base-line thresholds		
DATA ACQUISITION REVIEW: These checks are to make sure that the contractor collected the data as per the contractual requirements.	Nominal Pulse Spacing	Automated checks done by LiDAR project lead		
	Intensity Values	Automated checks done by LiDAR project lead		
	Data Voids	Visual checks by LiDAR technicians		
	Scan Angle	Automated checks done by LiDAR project lead		
	Swath Overlap	Automated checks done by LiDAR project lead		
	Sensor Anomalies	Visual checks by LiDAR technicians		

QC Checklist		Methodology	Contractual Requirements	Department Lead Sign-off
DATA CALIBRATION REVIEW: These checks are to ensure that the data meets the contractual accuracy requirements.	GPS-IMU Accuracy Review	Analysis of solution graphs		
	Vertical Accuracy	Vertical report against the check points		
	Relative Accuracy	Color coded DZ-Orthos for flight-line mismatches		
SURFACE QUALITY REVIEW: These checks are to ensure that the LiDAR point cloud is classified as per the contractual requirements.	Misclassification	Visual inspection of 100% of the data. Final QC is done by reviewing hillshades generated from the classified data		
	Noise			
	Artifacts			
	Surface consistency			
DATA COMPLETENESS & FORMATING REVIEW: These checks are to ensure that all the products listed in the contract are delivered, they are in the right formats and they completely cover the project area.	Delivery Layout	Confirmed by the client and signed off by department lead		
	LAS Format	Automated check done by LiDAR lead		
	Classification Levels	Automated check done by LiDAR lead		
	GPS Time	Automated check done by LiDAR lead		
	Horizontal Datum	Automated check done by LiDAR lead		
	Vertical Datum	Automated check done by LiDAR lead		
	Units	Automated check done by LiDAR lead		
	Coverage checks of deliverables	Visual checks done for each product type by LiDAR lead		
	Deliverables	LiDAR lead verifies that all the deliverables are produced and delivered		
	Breaklines Format	Checked by GIS lead		
	DEM Format and resolution	Checked by GIS lead		
	Metadata	Checked by LiDAR and GIS lead		

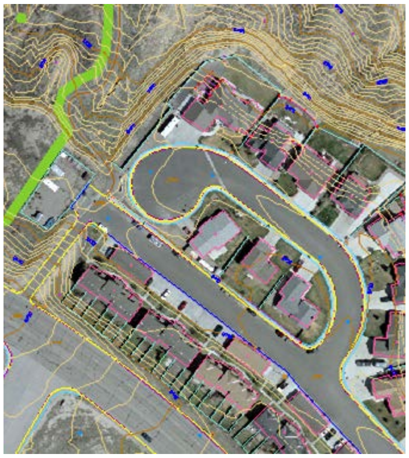
Option: Planimetric Mapping

Sanborn has extensive experience extracting planimetric data from aerial imagery for use in creating or updating GIS data layers using photogrammetric techniques. Sanborn will capture all feature layers as detailed in the RFP, depending on which are desired by each participant, in full conformance with the database design provided by COAGA 2015.

Sanborn will perform a manual, 3-Dimensional comprehensive review of the planimetric data, performed by an experienced stereo-compiler using high accuracy stereo-compilation machines.

The option for updated planimetric data layers is provided for Edmond, Choctaw, Moore, and Norman. All newly acquired planimetric data will meet or exceed ASPRS Class 1 specification; the existing data will meet the original compiled specification.

Feature Compilation



Sanborn will extract the desired planimetric features from the controlled aerial imagery in a 3D stereoscopic environment, utilizing first-order softcopy workstations operated by photogrammetrists experienced in photo interpretation to update or create the planimetric database, as appropriate to each feature class. The use of softcopy workstations utilizing stereo superimposition technology (planimetric features traced in vector form directly over the top of stereoscopic imagery displayed on the computer monitor) ensures accurate and complete collection of all mapped features. This approach not only provides an accurate horizontal position for the planimetric features, it also provides accurate elevation data where needed, as Sanborn collects a variety of planimetric features such a road edges, retaining walls, and hydrographic features in 3D.

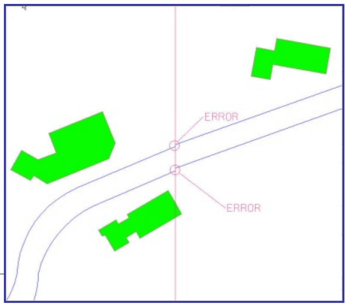
COAGA 2015 should note that there are limitations that impact our ability to fully and accurately capture some planimetric features, including:

- The scale/limits of resolution of the imagery
- Shadows
- Vegetation cover
- Roof overhangs
- Temporary structures such as mobile canopies
- Vehicles driving or parked over features
- Paved-over or dirt-covered features, or features that are very close in color to paved surfaces or dirt.

The database structure for the project will be uploaded to each softcopy workstation. Quality assurance steps will be in place during the data capture process to ensure that each required planimetric feature is collected to correct graphical representation, annotation and attribute requirements outlined in the data dictionary.

At the completion of the stereoscopic compilation tasks, the compiled model is reviewed using softcopy stereo-display to ensure that all data was compiled correctly. A senior photogrammetrist performs this review, with the specific responsibility of maintaining quality control of the project. The compiled file is superimposed over the source imagery, and the required planimetric features in areas of change are reviewed. If features are determined to be missing, or not properly merged into unchanged portions of the database, the location is marked in the file in a separate layer and a QC note is inserted with specific comments. The model will be recalled by the stereo compiler and any necessary corrections addressed. This procedure provides two-way communication, ensuring consistency of data collection in terms of content and interpretation. Once the data are complete and correct, the interactive graphic editing phase begins.

Interactive Graphic Editing and Topological Structuring of Data



Graphic editing procedures involve a combination of interactive and programmatic checks to ensure that the data is cartographically correct and aesthetically pleasing, connectivity of linework is complete, and specific layers of line topology are generated. A variety of topology checks are performed to ensure that all features defined as being topologically structured have no snapping errors (overshoots/undershoots). Polygon topology is created, attribution of features takes place, and edge-match checking between tiles of data is performed.

Edge Matching

Checking for tile edge mismatches is a standard part of all Sanborn projects for clients that tile their data. Using an automated process, each tile is checked against its neighboring tiles to ensure that all linework matches exactly. This ensures that attributes of the linework and/or polygon data are also checked. At the conclusion of the process, the graphic technician digitally reviews each tile and corrects any mismatches in line placement or attribution that were flagged by the edgematch routine. This process is repeated until no errors are flagged. Sanborn will ensure that planimetric features will meet all topology requirements when the data is migrated into the target environment, and make the transition to the GIS as efficient as possible.

Layers, Colors, Symbols, Linestyles, and Annotation

Sanborn will format all data layers as detailed in the data dictionary. All symbols, colors, linestyles, and annotation will follow COAGA 2015's desired conventions.

Sanborn's listing of data standards and criteria are summarized in the following table.

Data Standards and Criteria	
Edgematching	All data that crosses a tile/map sheet will be edge-matched and coordinate connectivity present.
Point Duplication	No duplicate structures or graphic entities will be allowed. No points will be duplicated within a data string. Points will not be duplicated across tile boundaries unless it corresponds to a delivery area.
Connectivity	Software checkable digitizing errors such as overshoots and undershoots will be eliminated as specified. Lines that intersect will join precisely.
Line Quality	All straight lines will contain only two points: beginning and end. A high graphic appearance shall be achieved. Transitions from straight line to arcs shall be smooth.
Segmentation	Linear elements will not be broken unless the break reflects a visual or attribute code characteristic.
Precision	All data capture will be accomplished in double precision.
Build and Clean	Data shall be built and clean, and no polygon-label errors will exist. Dangles and intersect errors may exist under certain circumstances in the line data but not in the polygon data.
Annotation Criteria	Placement, where required, will be visually consistent and uniform.
Symbology	All graphics will be consistent with the symbol specifications with respect to the character of the symbols, line weights, annotation fonts and sizes, symbol displacement (cartographic license), and special applications of the symbology.
Spatial Continuity	All delivered files will represent the specified data as spatially continuous. The data will be topologically structured and all polygons will be mathematically closed. All polygons have centroid label points.
Graphic Standards	All graphics will be consistent with accepted symbology and a high cartographic appearance shall be achieved.

Translation into Esri Geodatabase Format

Once the planimetric and DEM data are completely structured and edited, they are ready to be translated from Microstation .DGN to Esri Geodatabase format for delivery. Sanborn has a suite of proprietary translator software that enables the translation to various target systems, including the Esri environment.

As a final check on the deliverable data, and with COAGA 2015's database design as the foundation, Sanborn uses custom software modules to perform QA/QC checks within the Esri Geodatabase environment:

- Features and associated attributes are validated for data integrity
- Checks are performed to ensure consistent assignment of unique ID numbers
- Edgematching processes are run between files
- Data will be verified with the source data and documents for content (missing data) errors, annotation integrity, and aesthetics
- QA/QC reports are generated and checked for errors; they may include:
  - Ensure that all datasets have valid feature attribute tables (FATs)
  - Ensure that all datasets have valid values for fuzzy tolerance, dangle length, and precision
  - Verify point duplication
  - Verify line duplication or incorrect length
  - Verify polygon label errors and dangles
  - Verify attribute item definitions
  - Verify attribute value ranges
  - Verify attribute value combinations for multiple items in an attribute table
  - Verify valid annotation levels for a coverage
  - Verify pseudo node placement
  - Verify data outside appropriate boundaries
  - Verify data edgematching across tiles
  - Verify value/uniqueness for related tables
  - Verify size and symbol for given symbols or annotation

Compiling into Esri Geodatabase Format

Sanborn has the capability of compiling directly into an Esri geodatabase directly from the 3D stereoscopic environment using DAT/EM CAPTURE. All of the compilation methods and topology checks are the same as capture into Microstation without having to translate the data from a .dgn file into a database.

Certification of Compliance with Accuracy Standard

Following completion and passage of all internal and independent quality control checks, Mr. Doug Zehr, Chief Photogrammetrist and one of Sanborn's ASPRS Certified Photogrammetrists, will certify the product accuracy as meeting the accuracy requirements as set for the project by COAGA 2015. The detailed project plan prepared by the Project Manager will include comprehensive acceptance criteria, including the information outlined in the RFP, and review of interim products, such as the aerial triangulation results, that align with our rigorous ISO 9001:2008 internal quality control and quality assurance methods. Sanborn guarantees that rigorous testing to meet and certify to these standards for quality control for the project and deliverables will be performed. Sanborn has provided a comprehensive description of our quality control procedures following each production step in our workflow in the technical approach. The use of ground checkpoints to test the accuracy solution is described in the Analytical Aerotriangulation section.

Summary of Deliverables

Sanborn will provide a copy of all deliverables as outlined in the table below. All data will be quality controlled and in full compliance with the standards and specifications set forth by COAGA 2015 in the RFP.

Summary of Deliverables	
Deliverable	**Description**
Project Control	Sanborn will submit a comprehensive survey report documenting the survey in PDF format, and an Esri Geodatabase file with all of the coordinate data.
Flight Plans	Sanborn will deliver the final flight line map/photo index with photo centers in Esri Geodatabase and Adobe PDF formats.
Field Survey Report	Sanborn will submit a comprehensive report in PDF format documenting the ground control survey.
Aerial Triangulation	Sanborn will provide a fully-indexed AT report that will provide a narrative description of all aspects of the AT phase, tabular information for ground control and check point results, and appendices including full AT solution printouts. An Adobe .PDF version of the report and a Microsoft Excel file with the point coordinates will be provided as well.
Digital Orthophotography	Sanborn will provide a copy of all color orthoimagery tiles at the desired spatial resolution of 3-inch or 6-inches in (uncompressed) .TIFF/.TIFW format. Radiometry will be 3-band, 8-bit per channel RGB with compatible Esri 10.2 image catalog. The 4th band is offered on an optional basis to each participant, at no additional cost.
Compressed Files	A full set in MrSID compressed 1:20 and JP2000 format files with an Esri 10.2 compatible catalog
Orthoimagery Seam Lines	Sanborn will provide flight date attributed seam line vectors in Esri Geodatabase format.
Compressed Mosaics	Full citywide MrSID mosaics in .SID/.SDW *and* JP2000 files of the project area..SID/.SDW format with 20:1 compression. Radiometry will be3-band, 8-bit per channel RGB.
DEM	Sanborn will provide a copy of the updated digital elevation model created for use in orthorectification in Esri Geodatabase format.
Tile Index	Sanborn will provide the final tile layout in Esri Geodatabase format (tiled at approximately PLSS sections)
Planimetric Data	Sanborn will provide a copy of the planimetric data in Esri Geodatabase format.
LiDAR Data (Option) DEM	Hydro-Flattened Bare earth DEM

Summary of Deliverables	
Deliverable	**Description**
LiDAR Data (Option) DTM	Hydro-Flattened DTM ASCII TIN files
LiDAR Breaklines	Breaklines representing all hydrologically flattened features
LiDAR Accuracy Report	LiDAR Acquisition and Vertical accuracy Report
Contour Data (Option)	Sanborn will provide a copy of the contour data in Esri Geodatabase format.
Raw Point Cloud	Raw Point File in LAS 1.4 format
Metadata	Sanborn will provide FGDC compliant metadata for the project in the format of COAGA 2015's choosing.
Project Documentation	Sanborn will provide a copy of all required project documentation including reports regarding aircraft and camera operation, calibration reports, QA/QC reports, and management & administrative documents.
Deliverable Media	Final data will be delivered on USB External Hard Drives. DVD 2.0, 4.7 GB single sided (4.3 GB usable) disks or FTP download is also available for interim deliverables, such as pilot data sets.

QA/QC Program and Continuous Improvements

To assure our performance meets or exceeds COAGA 2015's requirements, Sanborn is fully implementing its proven ISO9001:2008 processes to assure all contract materials are delivered in accordance with COAGA 2015's expectations at the required accuracy and quality. Our key is a system that identifies any problems early in the workflow. Quality control validation points are inserted into the overall program process at key points and quality assurance protocols are completed prior to submission of deliverable products.

Sanborn has established key quality audit points in the photogrammetric data creation process. Checks of work products immediately following a key process step provide the opportunity to ensure that the data at that point are of acceptable quality for input to the next process step. Any data found defective are immediately returned to the previous step for correction or recollection.

Listed below are several key steps that will be initiated at the beginning of the project to support our Quality Plan.

- Sanborn will conduct a QA/QC technical work session with appropriate State representatives. This work session will be conducted during the initiation phase of the project. It will enable us to make sure that potential QA/QC issues are adequately addressed by Sanborn.
- Mr. Sanchit Agarwal, Director of Project Engineering and Quality, will be designated an internal, independent Quality Assurance authority for the duration of the program.
- Sanborn will work with COAGA 2015 to develop formal acceptance criteria for the final digital orthophotography. These criteria will document production standards for the final imagery.
- A detailed Quality Plan will be developed to be used in concert with the acceptance criteria. This document will include all checklists and forms to be used for quality reporting.
- Sanborn will conduct internal meetings with our managers and staff to ensure all team members have a full understanding of the project and quality control steps. Training sessions will be conducted as appropriate.

- Sanborn will also conduct a pilot program. This pilot will serve to test our QA/QC process and to make any necessary revisions as appropriate.
- The goal of this phase of the program is to implement a QA/QC program that is robust, comprehensive, and complementary of the procedures employed by COAGA 2015.

Sanborn uses an independent internal quality review process for all data to ensure adherence to product specifications, data formats and data completeness for all the deliverables across all phases of the contract. Sanborn spends considerable effort to ensure data quality. All data are post-processed in a controlled environment based on strict procedures, not only designed to maintain data integrity, but also to provide the best possible products to COAGA 2015. As a result, we use highly controlled procedures for planning, data acquisition, post-processing, ortho-production, product generation and data delivery. The following table is an outline of the Sanborn Quality procedures across all phases of the project.

QC Checklist		Methodology	Contract Requirements	Lead Sign-off
PRE-ACQUISITION REVIEW: These checks are to make sure flight-planning is done according to the contractual requirements.	Project Boundaries	Confirmed with COAGA 2015 by the Project Manager and released to the Acquisition Team after sign-off		
	Flight Plan	Checked by Acquisition Manager and submitted to client for review		
	Sensor Settings	Checked and verified by the Acquisition Manager		
	Weather conditions	Verified by the Operator		
	Survey Plan	Checked and verified by the Geomatics Engineer		
FIELD DATA REVIEW: These are the preliminary QC steps done by the Operator & Pilot	Flying Height Checks	Double check the flying height		
	Flight Logs	Flag the flight-lines with cloud coverage and turbulence		
	Sun Angle	Cross reference the sun-angle charts with the flight time		
	Coverage & Overlaps	The data is checked for side and forward overlap and any coverage issues		
POST ACQUISITION DATA REVIEW: These checks are to make sure that the collected data meets the contractual requirements.	Resolution	The resolution of the data is confirmed by the Lead		
	Image Quality	Image free of clouds, haze, over-exposure, saturation, artifacts		
	Data Voids	To ensure the coverage		
	Sun Angle	The data meets the sun-angle requirements		
	Overlaps	The data is checked for side and forward overlap		
DATA CALIBRATION REVIEW: These checks are to ensure that the	Initial Orientation Review	The initial orientation is checked for accuracy and completeness		

QC Checklist		Methodology	Contract Requirements	Lead Sign-off
data meets the contractual accuracy requirements.	Control Network Review	To ensure that the control network residuals are within the error budget		
	AT Accuracy Review	RMSE of the residuals on tie-points and control points		
DTM SURFACE REVIEW: These checks are to ensure that the DTM data going into the orthorectification process is up-to date	Review of the Existing DTM	By surface subtraction between the old and new DTM		
	Update of the DTM	The DTM is updated in the areas of change		
	Horizontal & Vertical Accuracy	Check the horizontal & vertical registration between the DTM and the AT		
ORTHO PRODUCTION REVIEW: These checks are performed during the ortho-production processes	Seamline Editing	All seam-lines are QC'ed and modified accordingly		
	Smearing	The orthos are checked thoroughly for feature smearing		
	Color Balancing	The Orthos are QC'ed and corrected for any color balancing discrepancies		
	Ortho Accuracy	The ortho accuracy is checked by measuring the control and check points on the orthos		
DELIVERY COMPLETENESS & FORMATTING REVIEW: These checks are to ensure that all the products listed in the contract are delivered, they are in the right formats and they completely cover the project area	Delivery Layout	Confirmed by COAGA 2015 and signed off by Department Lead		
	Imagery Format	Confirmed by the Lead		
	Horizontal Datum	Confirmed by the Lead		
	Vertical Datum	Confirmed by the Lead		
	Unity	Confirmed by the Lead		
	Coverage Check of Deliverables	Visual checks done for each product type by Lead		
	Automated Header Checks	To ensure that all products are generated for delivery in the right formats (including reports)		
	Metadata	Checked by the Lead		

ISO 9001:2008 Certification

Sanborn has earned an ISO 9001:2008 certification and is registered with Platinum Registration, Inc. (Platinum). ISO 9000, a Quality Management System Standard, is a series of five international standards that provide guidance in the development and implementation of a specific Quality Management System.

With Sanborn's ISO 9001:2008 certification, COAGA 2015 is assured that:

- The requirements and specifications of the project have been thoroughly and rigorously evaluated and documented
- The production processes and procedures employed for the project are appropriate and adequate to produce the results intended
- The production processes and procedures are controlled and results will be consistent and repeatable
- Documentation will be maintained that allows for evaluation of the processes and procedures to eliminate the sources of nonconformities and to facilitate continual improvement of the processes and procedures
- Adequate facilities are available to meet the needs of the project
- Sufficient numbers of competent and adequately trained employees are working on the project

Resources and Equipment

The combination of the Sanborn team's extensive hardware resources, commercial and proprietary software, and personnel who are experts in their fields, serves to uphold our position as a leading provider of geospatial services and products. Sanborn is one of the few firms in the mapping business that has the ability to generate large volumes of quality digital data, which results in quicker turnaround times and reduced costs from acquisition to finished products. Investment in IT infrastructure is a priority across our corporation. Sanborn's production IT infrastructure is made up of a powerful 110 node computer farm and more than 1 petabyte of raw storage. The Tier 1 storage is capable of sustaining a data through-put of 700 Mb/s while the Tier 2 storage sustains throughputs of 200 Mb/s. To put this in perspective, most mapping firms acquire and process 35,000 exposures annually; in contrast Sanborn acquires five times this amount of imagery every year, and processes ten times this amount on an annual basis. Our sophisticated tools and processing power give Sanborn a competitive advantage for delivering large volume datasets in a short period of time while maintaining very competitive cost models.

Equipment

Sanborn performs data processing functions with external software, proprietary software, and specialized computer systems—they are the foundation of Sanborn's technology. We continuously update and replace our equipment and software as quickly as it becomes available on the market. Our personnel attend and participate in technical conferences and seminars so they can stay abreast of future industry trends.

The combination of Sanborn's extensive hardware collection, commercial and proprietary software, and personnel who are experts in their fields serves to uphold our position as a leading provider of geospatial services and products.

The abundance of Sanborn's resources allows for simultaneous processing of numerous major projects without impacting production schedules. This means we can save our customers time and money without sacrificing quality. Sanborn owns all of the equipment listed in the following tables.

Data Acquisition

Hardware/Software	Item Name/Model or Version	#	Remarks
Acquisition Resources			
Aircraft	Cessna TU206F	1	Sanborn has numerous additional flying partners with high performance aircraft outfitted for aerial photography and LiDAR missions
	Cessna TU206G	2	
	AeroCommander 500S	1	
	AeroCommander 500B	1	
	AeroCommander 680FL	1	
	AeroCommander 680W	1	
	AeroCommander 690B	1	
	AeroCommander 690A	2	
	Piper Navajo PA	2	
Cameras/Sensors	Vexcel UltraCam Eagle	1	100mm with POSTrack FMS and LN200 IMU
	Vexcel UltraCam Eagle	2	100mm with Ultranav FMS and Type 46, non-itar IMU
	I-One oblique sensor	1	POS-AV with LN200 IMU
	Leica ALS-70	1	LiDAR sensor with iPAS and LN200 IMU
	MIDAS Oblique Imagery Sensor (Canon)	2	50mm Nadir, 85mm oblique, POS-AV/Track'Air with LN200 IMU
	MIDAS Oblique Imagery Sensor (Nikon)	1	50mm Nadir, 85mm oblique, POS-AV/Track'Air with Type 46, non-itar IMU
Flight Planning, Navigation, and ABGPS Post Processing	TRACK'AIR Flight Management System/FM	2	Used for pinpoint aerial photography
	Applanix POS/AV w/IMU System/510	5	
	Garmin Navigation System/GPSMAP 496	2	Navigation and weather radar
GIS Software	Applanix POS PAC/FM	11	Used for ABGPS post processing
	Waypoint GrafNav Kinematic GPS Post Processing/FM	6	Used for airborne GPS (AGPS) post-processing
Field Survey			
3D Terrain/Feature Scanning System	Trimble 3-D Laser Scanner/GX Advanced	1	Scanning motorized through 360°, 200 m optimized range, 350 m OverScan capability, 700 m addressability, Up to 5,000 points/sec, Dynamic filtering
	Trimble Realworks	1	Terrestrial LiDAR Software that filters LiDAR , extracts linework , geometry, and solids
	Auto Correlation Filtering SW/FM	1	This sophisticated software utility can combine photogrammetrically digitized mass points and breaklines with data from LiDAR and terrestrial 3D imaging systems. Differential weighting in the least squares surface estimation can accommodate data of varying accuracy AC filtering operates on all file types
Misc. Equipment	Pentium Laptop Computers/Various	4	Sanborn has various field survey vehicles, ancillary survey equipment (tripods, etc.), and equipment such as augers for setting permanent monumentation
	Field Vehicles/Various	4	
	Tripods/Various	34	
	Two-Way CB Radios/Motorola	5	
GPS Equipment and Software	Novatel DL4+ GPS receivers	12	Receivers that are usually used for ground control/geodetic surveys. Many have RTK capability, TSCE data collectors, pen-based computers, and software
	Trimble SPS850 and R8 GNSS Receivers with RTK HPB450 Radios, and RTK cellular modems	2	
	Trimble RTK Dual Frequency Rover & Radio/5700	5	
	Digital Level/NA2000	1	Sanborn has a full array of specialized high precision equipment including optical plummets, translation stages, and optical metrology equipment for operations such as deformation monitoring
	Trimble TSC2 Survey Controller	2	
	Handheld GPS Units (Trimble, Garmin, Magellan)/Various	5	
	Topcon SPS850	3	
	Leica Total Station/T1800	1	
	IPAC Pocket PC/H2200	1	
	Trimble Business Center 3.10	2	Trimble's newest general purpose processing/data management software, including the post-processing of static geodetic quality GPS data
	Trimble GPSurvey	5	Post-processing of static geodetic quality GPS data
	Airlink Cellular RTK System	1	

* Full Maintenance (FM) - in most cases SW is upgraded and supported to latest available version

Mobile Mapping			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
System/Software	Optech Lynx	1	
	200 Khz Laser Head	2	
	5 MP Color Cameras	4	
	Applanix MMS System	1	
	LN200 IMU	1	
	Applanix POSLV	1	
	Applanix POS PAC MMS	1	

Terrestrial Mapping			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
System/Software	Trimble GX Advanced	1	
	Tripods	3	
	Trimble Laser Targets	6	
	Target Bi-pods	6	

Photogrammetry			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
Aerial Triangulation and Compilation			
Softcopy Photogrammetry Hardware and Software	Autometric Stereo SoftPlotters/FM	1	
	Bentley Microstation	34	Version v8i
	Bingo Adjustment/FM	1	
	DATEM Summit Evolution Stereo Softcopy Station	2	
	Intergraph ISAE, ISSD, ISFC, ISDC	*	Photogrammetry Compilation modules *Temporary licenses can be obtained on an as-needed basis
	Intergraph Softcopy Photogrammetric Workstation/SSK	*	Stereo Model Compilation workstations *Temporary licenses can be obtained on an as-needed basis
	Trimble INPHO Match-AT	4	Version 5.5.1
	DATEM-Summit Evolution Professional Microstation	2	
	DATEM-Summit Evolution Feature Collection Microstation	2	
	DATEM-Summit Evolution Feature Collection ArcGIS	3	
	DATEM-Summit Evolution Feature Collection AutoCAD	1	
	Stereo SOCET/FM	2	

GIS			
	Item Name/Model or Version	**#**	**Remarks**
Graphic Editing/GIS			
GIS Software & Development Software	ArcGIS/INFO and Associated Modules/FM	54	Version 10
	ArcCOGO/FM	2	Version 10
	ArcEditor/FM	3	Version 10
	ArcIMS/FM	3	Version 9.0
	ArcLP360/FM	4	Version 10
	ArcPAD/FM	8	Version 6
	ArcPress/FM	1	Version 10
	ArcPublisher/FM	1	Version 10
	ArcScan/FM	1	Version 10
	ArcSDE/FM	2	Version 10
	Adobe Acrobat Professional/FM	20	7.0
	Adobe Lightroom	37	
	CodeSmith Station/FM	1	4.1
	Data Interoperability/FM	4	Version 9.3
	EDN/FM	7	Version 9.3
	ERDAS Imagine/FM	5	9.1
	ET Geowizards /FM	2	9.8
	GeoStatistical Analyst/FM	3	Version 9.3
	GeoCue/FM	5	5.0
	Global Mapper /FM	2	6.0
	PLTS GISDataReviewer/FM	1	Version 9.3
	Python/FM	12	Version 2.5
	CommVault/FM	3	Simpana 7
	SDE Connects/FM	11	Version 9.3
	Spatial Analyst/FM	25	Version 9.3
	Survey Analyst/FM	1	Version 9.3
	3D Analyst/FM	9	Version 9.3
	Visio Professional/FM	3	2000
	Visual Basic/FM		VB.net
CADD			
CADD Software	AutoCAD Map 3D 2009 /FM	2	2009
	AutoCAD (Including Raster Design, Survey, Civil Design, Civil 3D, and Map 3D)/FM		2004
	Datem AutoCAD Map Editor/FM	1	2004
	Bentley Microstation/FM	39	Version v8i
	Datem Microstation Map Editor/FM	1	Version 8

Orthophotography			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
Ortho Processing Software and Hardware	Adobe Photoshop/FM	29	Version CS5
	Adobe Illustrator/FM	10	
	APS 3-D Workstation	1	w/3D glasses and emitter
	APS Graphic and Image Processing/Editing System/FM (Sanborn Proprietary Software)	Unlimited	APS software is used for editing and enhancing data and to develop topology and continuity for quality control and aesthetic enhancement. Produces accurate, consistent, and aesthetic GIS products for our clients
	Bentley Descartes Image Processing/FM	1	
	Blue Marble Raster Transformation/FM	1	
	Blue Marble Coordinate Calculator/FM	1	
	Cubist/FM	3	
	Ecognition Professional/Image Analysis/FM	7	
	ERDAS Imagine/FM	15	Version 2011 Robust image processing and GIS modeling software for analyzing a variety of aerial and satellite image products including panchromatic and multispectral/hyperspectral imagery and RADAR. Also supports complex 3D modeling and visualization applications
	Feature Analyst/FM	2	
	Imagination/FM	1	
	Metro Express – High-Speed Imaging Process System/FM (Sanborn Proprietary Software)	Unlimited	Internal Sanborn software that creates high quality enhanced orthoimagery, including automated true orthophoto production
	Metro ortho-processing software	Unlimited	
	MrSID (GeoExpress & Geospatial Encoder)/FM	14	
	Trimble INPHO Applications Master	Unlimited	Version 5.5.1
	Trimble INPHO Seam Editor	3	Version 5.5.1
	Trimble INPHO OrthoVista/FM	3	Version 5.5.1
	See5/FM	3	
	Softdesk CAD-Overlay GSX/Image Processing/FM	4	

IT Infrastructure			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
Graphic Editing/GIS			
Production Hardware	Data Storage/Central Network - Petabytes	1.3	Sanborn's business systems extensive hardware collection, serves to uphold our position as a leading provider of GIS services specialized computer systems—they are the foundation of Sanborn's technology The abundance of Sanborn's resources allows for simultaneous processing of numerous major projects without impacting production schedules. or sacrificing quality
	Dedicated Distributed Processing Servers/ Workstations/Workmates/Various	400	
	Servers/HP, Dell, Super Micron	25	Software Development
	Pentium Laptops/Various	50	Resources include state-of-the-art Extreme Network switches and a Spectralogic 10000 robotic tape back-up system
	High-Resolution Color Monitors/Various	261	
	Printers/Plotters/Various	34	
	Tape Drives (100 GB/200 GB compress)/AIT3	4	
	Tape Drives (160 GB/320 GB compress)/DLT	2	
	Tape Drives (400 GB/800 GB compress)/LTO3	8	
	External Hard Drives (100 MB - 1 TB)/Various	500	
	Internet Connectivity OC3	1	

LiDAR Data Acquisition Equipment			
Hardware/Software	**Item Name/Model or Version**	**#**	**Remarks**
Field Survey			
Survey Equipment	Pentium Laptop Computers/Various	4	Sanborn has various field survey vehicles, ancillary survey equipment (tripods, etc.), and equipment such as augers for setting permanent monumentation
	Field Vehicles/Various	8	
	Digital Level/NA2000	1	Including a pair of bar-coded invar rods; 8 geodetic levels in total
GPS Equipment and Software	Trimble RTK Dual Frequency Rover & Radio/5700/Trimble 4000SI w/ L1 L2 Ant	5	Receivers that are usually used for ground control/geodetic surveys. Many have RTK capability, TSCE data collectors, pen-based computers, and software
	Delorme EarthMate USB Antennas/LT-20	2	Sanborn has a full array of specialized high precision equipment including optical plummets, translation stages, and optical metrology equipment for operations such as deformation monitoring
	Handheld GPS Units (Trimble, Garmin, Magellan)/Various	5	
	Javad Geodetic Grade Dual Freq Receivers/Legacy-E	4	
	Fujitsu Stylistic Tablet PC/ST5000	1	
	Leica Backpack Unit/GS5+	1	
	Leica Total Station/T1800	1	
	Trimble Geomatics Office/FM / GPSurvey / Trimble TDC1 Survey Controller & SW/FM	9	Trimble's newest general purpose processing/data management software, including the post-processing of static geodetic quality GPS data / Post-processing of static geodetic quality GPS data
Acquisition Resources			
Sensors	Leica LiDAR Sensor/ALS70 (MPia)	1	200 kilohertz laser repetition rate, 0-70 degree swath angle, Four returns recorded, Intensities recorded
	Applanix DSS 439	1	39 megapixel camera, RGB or IR image, 60 mm lens, Coupled with Leica ALS50(II)(MPia)
AGPS/INS	Novatel GPS Receivers/Millennium DL, DL4 + L1/L2, 600	12	The Millennium receivers are used for airborne GPS/INS operations and LiDAR support
	Applanix POSproc/FM	11	Advanced Kalman filtering software—used for postprocessing/combining GPS and IMU data.
	QCoherent LiDAR/FM	10	
Processing			
Processing Software	ALS Post Processor	8	Raw Leica Range data processing and calibration software
	ALTM LiDAR Processing – Realm (3) Dashmap (2)	5	Raw Optech Range data processing and calibration software
	ALTM-NAV	3	Flight planning and flight management software for Optech
	Applanix POS PAC 5.1	11	
	ArcInfo/ArcEditor (3D Analyst, Spatial Analyst)	30	
	GeoCue (LiDAR Cuepak)	10	LiDAR Production management and LiDARgrammetry software
	Qcoherent L360	10	Manual QC/Editing of LiDAR and Product generation. Filtering, project management and visualization
	Virtual Geomatics VG4D	4	
	TerraModel DTM/Contour	9	Generation of DTM and Contours
	Terra Solid Terramodeler / TerraScan	17	For classification and manipulation of LiDAR data
	Waypoint GrafNav Kinematic GPS Post Processing	5	Used for airborne GPS (AGPS) post-processing

Section 3 – Management Proposal

Project Management

Sanborn's project management approach rigorously applies the Project Management Institute (PMI) model, which exceeds the requirements of ISO 9001:2008. Sanborn understands that an upfront investment in planning results in the best outcome for the entire project lifecycle. The PMI model encompasses the following knowledge areas and process phases:

- Integration
- Scope
- Time
- Cost
- Quality
- Human Resources
- Communications
- Risk
- Procurement

Project Manager

Sanborn's Project Manager for the Montgomery County Commission's program will be Mr. Kristopher Andersen. Mr. Andersen has over 15 years of experience managing Geospatial programs, including statewide collections for Michigan and Louisiana as well as large programs for Maricopa County, AZ; the Southern Nevada Water Authority; Pima Association of Governments, AZ; and the Southern California Council of Governments. Mr. Andersen has extensive experience in managing all phases of imagery and mapping projects, and as project manager, he has had direct accountability for advanced project design, program financial design and management, program execution, risk management, and schedule management. Mr. Andersen is trained in Agile Delivery Methodologies and uses the latest collaboration tools to ensure all program stakeholders are kept informed on program progress.

In general, Mr. Andersen will be responsible for project definition, production oversight, scheduling, quality management, and financial and contractual management.

Project Definition

Project definition at Sanborn begins with the preparation of a project charter that encompasses all elements of the program. The project charter establishes the overall goals, vision, organizational structure, project structure, deliverables, management plans and approach, technical baseline, schedule, cost, subcontract management, quality, and other key elements of the program. All the methods used to plan, monitor, and control the project are also identified in the project charter.

A key element of the project definition is the development of the project schedule in our Primavera Enterprise® software (Primavera), in addition to multiple supplementary tracking systems. This project management and production tool is used to develop and track all project resources and the schedule throughout the life of the project. The Primavera schedule is the single source for all project status and tracking throughout the life of the project. A baseline contractual schedule is maintained in addition to multiple scenario schedules.

Project Initiation

Sanborn believes that the key to any successful project is continuous customer communication. Soon after contract award, Sanborn will request a preliminary planning meeting to identify any specific items that may have arisen after reviewing numerous proposals that may not have been in the original RFP. Once this information is gathered and the project charter is complete, Sanborn will request a "kickoff" meeting where Sanborn's management team and appropriate Sanborn production staff will meet with appropriate COAGA 2015 staff to:

- Review the technical requirements of the project against the proposed technical plan contained in Sanborn's proposal.
- Review the sources that are to be supplied by COAGA 2015 against the requirements and expectations of Sanborn's proposed work plan.
- Review the acquisition plan requirements and flight plans.
- Review the preliminary work plan (and the quality control processes and procedures) as presented in Sanborn's proposal against defined delivery areas or work packages.
- Review the estimated resource plan.
- Review the project-specific Quality Plan presented at the meeting by Sanborn. Included will be a review the product acceptance procedures, methods and criteria that will be used by COAGA 2015 to determine product conformance with product specifications.
- Review the proposed project schedule and finalize interim and final delivery dates
- Review the schedule requirements by specific work tasks and the interdependencies of the sources of information to be supplied by COAGA 2015
- Define the parameters of a pilot or prototype project where the proposed procedures will be tested for their ability to meet product specifications and/or the ability of the product specifications to meet the needs of COAGA 2015
- Define a formal change management process designed to effectively and efficiently track proposed modifications to contracts. This process will allow COAGA 2015 to make cost and benefit tradeoffs based on an analysis of the requested changes. It allows for the design, development, and implementation of modifications to production processes and procedures to be made in a controlled manner.
- Define all communication protocols and procedures that are necessary for effectively ensuring that both parties to the contract are informed about the production departments' progress on each project task, that the sources are effective for the purpose intended, and the status of deliverable product reviews by COAGA 2015.

We anticipate that the kickoff meeting will be held at COAGA 2015's offices, but we welcome a site visit to our production facilities at any time throughout the course of the project.

Production Schedule

Mr. Andersen will review the production schedule contained in Sanborn's proposal during the project initiation meeting. This draft schedule, based upon our review of the RFP, may be re-evaluated after the completion of the pilot or prototype project and before the balance of the project is started, depending upon comments received by COAGA 2015, if they impact the scope of work. It is anticipated that COAGA 2015 will review the pilot deliverables and provide comments to Sanborn within five days of receipt. If necessary, the resource requirements will be input/revised in the Primavera system at both of these milestones before production of the balance of the project commences.

Sanborn's proposed project schedule is provided in Section X, Delivery Schedule, of this proposal response, for COAGA 2015's review.

Financial Schedule

Mr. Andersen will develop an internal set of financial budgets based upon the input into the Primavera system and an invoice and payment schedule that is tied to production and/or terms and conditions in the contract. Mr. Andersen is responsible for the timely and accurate submission of invoices to COAGA 2015. COAGA 2015 is obligated to remit timely and accurate payments in accordance with the terms and conditions of the contract.

Preferred Payment Schedule

Sanborn proposes a milestone invoice schedule in coordination with the delivery schedule:

- 10% upon survey and flight plan approval
- 30% upon acquisition completion
- 20% upon survey report and AT report delivery
- 30% upon initial orthophoto/planimetric/topography delivery by area
- 10% upon final acceptance

Sanborn is willing to negotiate other terms for invoicing if desired.

Quality Management System

Sanborn has earned ISO 9001:2008 certification and is registered with Platinum Registration, Inc. ISO 9001, a Quality System Standard, is a series of five international standards that provide guidance in the development and implementation of a specific Quality Management System. With Sanborn's ISO 9001:2008 certification, COAGA 2015 is assured that:

- The requirements and specifications of the project have been thoroughly and rigorously evaluated and documented
- The production processes and procedures employed for the project are appropriate and adequate to produce the results intended
- The production processes and procedures are controlled and results will be consistent and repeatable

- Documentation will be maintained that allows for evaluation of the processes and procedures to eliminate the source of nonconformities and to facilitate continual improvement of the processes and procedures
- Adequate facilities are available to meet the needs of the project
- Sufficient numbers of competent and adequately trained employees are working on the project

Sanborn's Quality Management System has been developed to ensure that adequate and continuous control is in operation for all activities affecting product quality. Where specific regulatory requirements affect our processes, our procedures and instructions will be designed or revised to meet such requirements. Sanborn employs methods and techniques that foster continuous improvement and good business practice.

Sanborn places an emphasis on problem prevention rather than dependence on detection after occurrence. Every effort is made to perform operations and quality-related activities correctly the first time. The Quality Management System includes a formal review of the parameters affecting product quality from conception to contractual fulfillment. Whenever necessary, corrective and preventive actions are implemented to ensure continuous improvement.

Responsibilities

Sanborn staff members are aware of what they are authorized to undertake and are responsible for achieving. This is ensured by documentation of responsibilities and authorities in specific procedures. All employees are responsible for following applicable policies, procedures, and work instructions. Additionally, every employee has the responsibility and authority to:

- Initiate action to prevent the occurrence of any nonconformities relating to product, process, and the Quality Management System
- Identify and record any problems relating to the product, process, and the Quality Management System
- Initiate, recommend, or provide solutions through designated channels
- Control further processing and delivery of products until the deficiency has been corrected
- Ensure that COAGA 2015's source materials and other property, including intellectual property, is logged, utilized, stored, and returned in a controlled manner

Roles and Responsibilities of COAGA 2015

Sanborn proposes that COAGA 2015 roles and responsibilities under this program will be to:

- Coordinate and communicate with Sanborn
- Process all contractually-related documents in a timely manner
- Review Sanborn's flight plans and related documents, and provide comments or approval in a timely manner
- Respond in a timely manner to requests for information, data, and meetings or conference calls
- Perform reviews and quality control checks of interim and final deliverables in a timely manner and communicate the results to Sanborn
- Review and pay Sanborn's invoices in a timely manner.

Communications Management

Customer communication and status reporting is the most important aspect of project management. The continuous communication between Sanborn and COAGA 2015 will provide insight to the project process and eliminate gaps in communication on technical and schedule issues. Sanborn has a proven method of communication with our customers, and will review with COAGA 2015 the best method to ensure constant contact throughout the project lifecycle.

Communication requirements will be incorporated and documented in the work plan. The specific requirements for each project are unique; therefore, the tracking and reporting tools and procedures necessary for effectively managing the project are established specifically for COAGA 2015's project and maintained throughout the term of the contract.

Meetings and Conference Calls

Meeting minutes from project team meetings and conference calls will be produced and distributed by Mr. Andersen. These minutes shall include descriptions of the issues discussed during the meeting, their resolutions, and the necessary follow-up. All project records, including correspondence, reports, invoices, and specifications, will be maintained in the project files by Mr. Andersen.

Project Tracking and Status Reporting

Sanborn is committed to successful internal performance management and to providing customers with easy access to the status of their projects. We accomplish this by using a variety of proven tools.

Project Status Reporting is one of the most critical aspects of communication for large projects with many players and variables. As a result, Sanborn utilizes four primary technologies to provide update information about the project to COAGA 2015 including real-time web-based tracking reports.

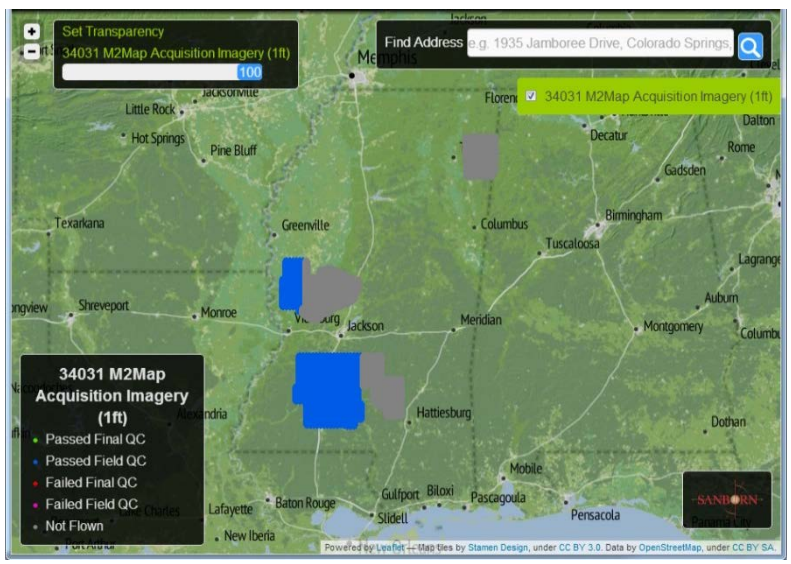
1. **Written Status Reports –** Mr. Andersen will submit a weekly Project Status Report to provide project team members with a common understanding of the important issues, procedures, and goals associated with the project. The report summarizes project activities completed over the past reporting period and those planned over the next similar time period. Information addressed in the Project Status Report includes the following:
   - Major activities completed during the most recent reporting period
   - Summary of data production status, including but not limited to listing of data accepted by COAGA 2015 and the status of COAGA 2015's review of delivered data
   - Description of current project issues and procedures
   - Activities to be completed over the next reporting period
   - Data production forecasts for the next reporting period
   - List of requested action items
   - List of outstanding issues/action items
2. **Status Calls –** Weekly status calls can also be held with COAGA 2015 to coordinate project activities and to review open issues noted in the status report. Exact times will be established with COAGA 2015 during the project initiation meetings. It is the Sanborn

project manager's responsibility to facilitate this call, document new actions, address the status of open issues, and assign action items. A sample agenda is as follows:

- Major issues and action items completed for a specified time period
- Critical issues and actions not completed and their potential impacts including, but not limited to, COAGA 2015's review of deliverables and the schedule for source data delivery
- Production status
- Action items for next reporting period
- Upcoming action items and questions

3. **Web-Based Reporting / Program Status via SanTrack –** Sanborn recognizes the importance of enabling our clients to gather information on the status of their projects during acquisition and production. Being able to anticipate deliveries and to gather information on your projects status without relying on project management or production personnel can be very important (if not critical) at times. Understanding this need, Sanborn developed a system that provides our clients with the ability to view the status of their projects through an Internet connection.

   SanTrack is Sanborn's method of visually tracking projects internally while at the same time allowing our clients to view the status of their projects. This browser-based viewing system allows clients to check the status of their projects at any time. SanTrack, which is strictly for viewing purposes, is accessible via the Internet using standard web browser. No additional client-side software is required. SanTrack allows for daily progress from all team members to be entered and displayed. Our Program Manager will ensure the SanTrack website is updated on a daily basis for acquisition and on a weekly basis for all other tasks.



   The web-based online status viewer will reflect a status for each tile or block as appropriate. Information posted to the status reporting site includes, but is not limited to, progress for aerial imagery acquisition, imagery processing, analytical triangulation, rectification, and delivery of data.

4. **Web-based SharePoint Site –** Our proposal assumes we will develop a project website to be accessible through our internal Intranet as well as the Internet. This tool will facilitate communication, document control, and standardization of procedures for both internal and external project /task management. This website will be designed specifically for COAGA 2015's project, and confidentially secured by user login and password.

   Project home pages provide hyperlinks to project reference documents, specifications, productivity and quality data, project status reports, technical support requests, and can be the primary mechanism for distributing status reports. Instituting this for COAGA 2015 would greatly improve project communications and tracking. This technology will benefit this project and COAGA 2015 by:

- Providing easy distribution of project updates, alleviating total reliance on email, faxes, etc.
- Providing summary and detailed level reporting, as well as sorting information by category.

Quality Control

Sanborn will follow its proven ISO9001:2008 processes to ensure that all contract materials are delivered in accordance with COAGA 2015's requirements. Our key is a system that identifies any problems early in the workflow. Quality control validation points are inserted into the overall program process at key points and quality assurance protocols are completed prior to submission of deliverable products.

Sanborn has established key quality audit points in the data creation process. Checks of work products immediately following a key process step provide the opportunity to ensure that the data at that point are of acceptable quality for input to the next process step. Any data found defective is immediately returned to the previous step for correction or recollection.

Listed below are several key steps that will be initiated at the beginning of the project to support our Quality Plan:

- Sanborn will conduct a QA/QC technical work session with appropriate COAGA 2015 representatives. This work session will be conducted during the initiation phase of the project. It will enable us to make sure that potential QA/QC issues are adequately addressed by Sanborn.
- Sanborn will designate a Quality Assurance Manager.
- Sanborn will review COAGA 2015's formal acceptance criteria for the final deliverables. We understand that the samples delivered as part of the pilot/prototype phase of this program are an integral part of understanding the acceptance criteria and ensuring they are met. Results of the pilot project will refine production guidelines for full production and creation of final deliverables.
- A detailed Quality Plan will be developed to be used in concert with the acceptance criteria. This document will include all checklists and forms to be used for quality reporting.
- Sanborn will conduct internal meetings with our managers and staff to ensure all team members have a full understanding of the project and quality control steps. Training sessions will be conducted as appropriate.
- Sanborn will also conduct an internal pilot program. This pilot will serve to test our QA/QC process and to make any necessary revisions as appropriate.
- The goal of this phase of the program is to implement a QA/QC program that is robust, comprehensive, and complementary of the procedures employed by COAGA 2015.

Sanborn has provided a comprehensive description of our ISO 9001:2008-based quality control procedures following each production step in our workflow in the technical approach above. Please see our technical approach for a specific description of quality control procedures for each key step of our production process.

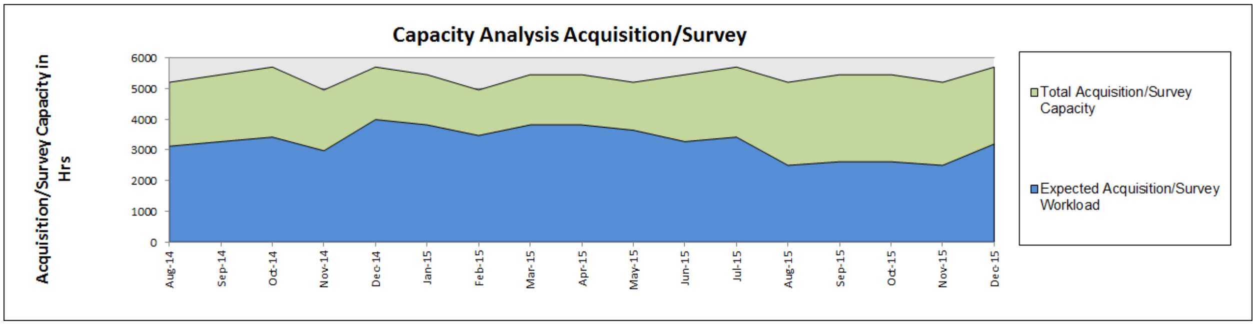
Capacity and Schedule

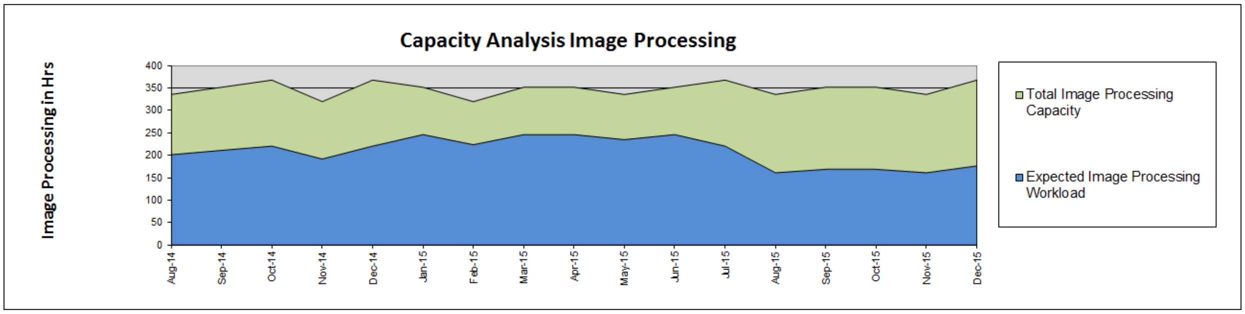
The combination of Sanborn's extensive hardware collection, commercial and proprietary software, and personnel who are experts in their fields, serves to uphold our position as a leading provider of geospatial services and products.

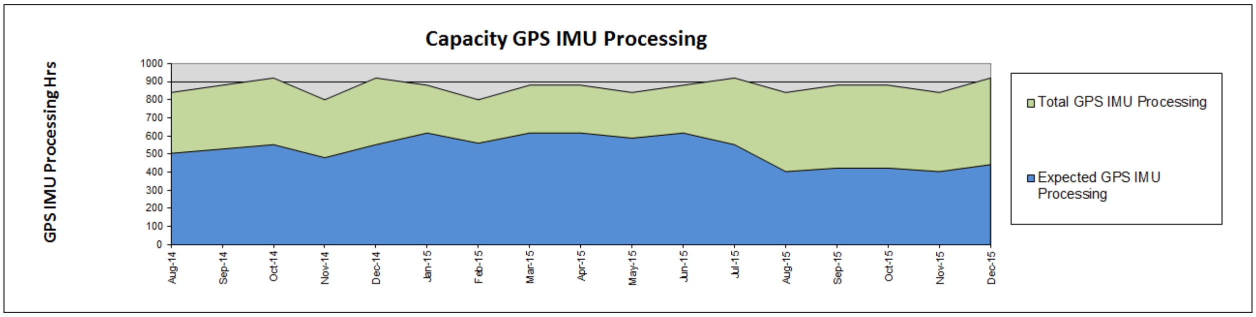
Sanborn's Primavera environment enables integrated management of the entire project lifecycle, from design and proposal development, to implementation, and change management. Project schedules and resource allocations are modeled in Primavera as early as the proposal stage, then developed and maintained over the entire life of the project. For COAGA 2015's program, as the collection and processing moves through the timeframes, updates to Primavera allows Sanborn to reallocate resource if necessary and to direct additional assets to cover equipment failures, weather problems or changes in the capacity plan as a result in changes in the collection activity.

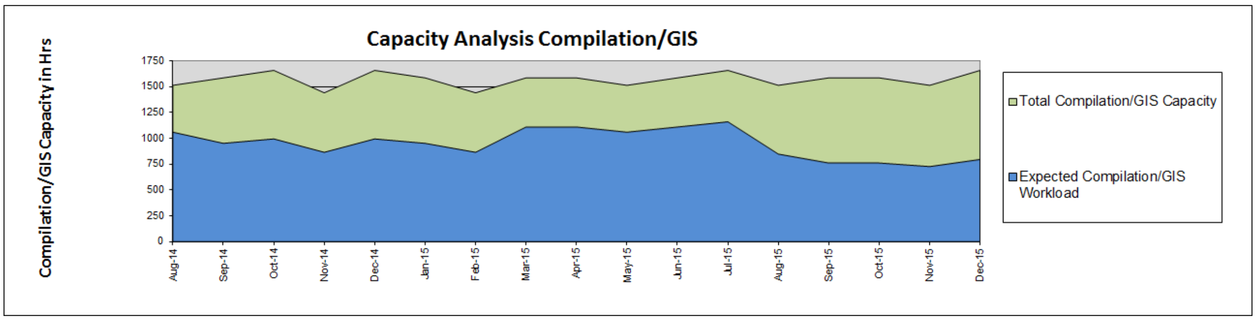
Sanborn has the ability to assume the significant scale of COAGA 2015's project with our available resources and key personnel. Sanborn's current and anticipated workloads do not directly conflict with COAGA 2015's acquisition and production window. Sanborn actively tracks total capacity, capacity against existing workload, and capacity against existing workload with new anticpated programs; and, performs six- to twelve-month look-ahead analyses in order to adjust for variation in the need for production resources proactively and dynamically, and ensure that resource adjustments do not need to be made in "crisis mode" in order to ensure schedule compliance.

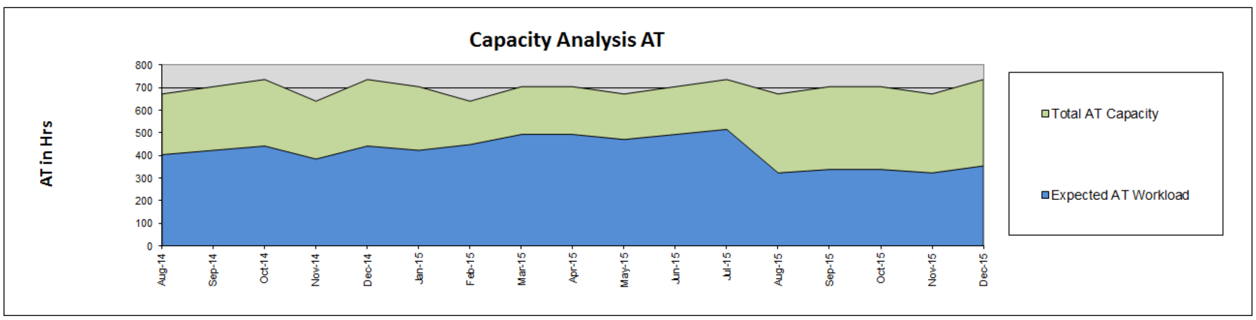
Below are graphs documenting our Primavera resource analyses. The graphs show significant capacity for airborne data acquisition, airborne GPS/IMU processing, image processing (pre-rectification), compilation/GIS (DEM ingest and update), aerotriangulation, and imagery post processing (orthorectification). Based upon this analysis, Sanborn has plenty of capacity to take on the proposed scope of work.

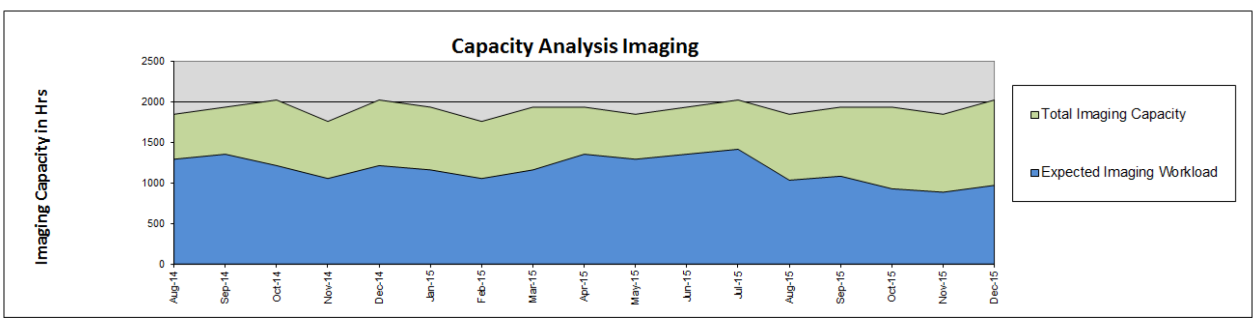










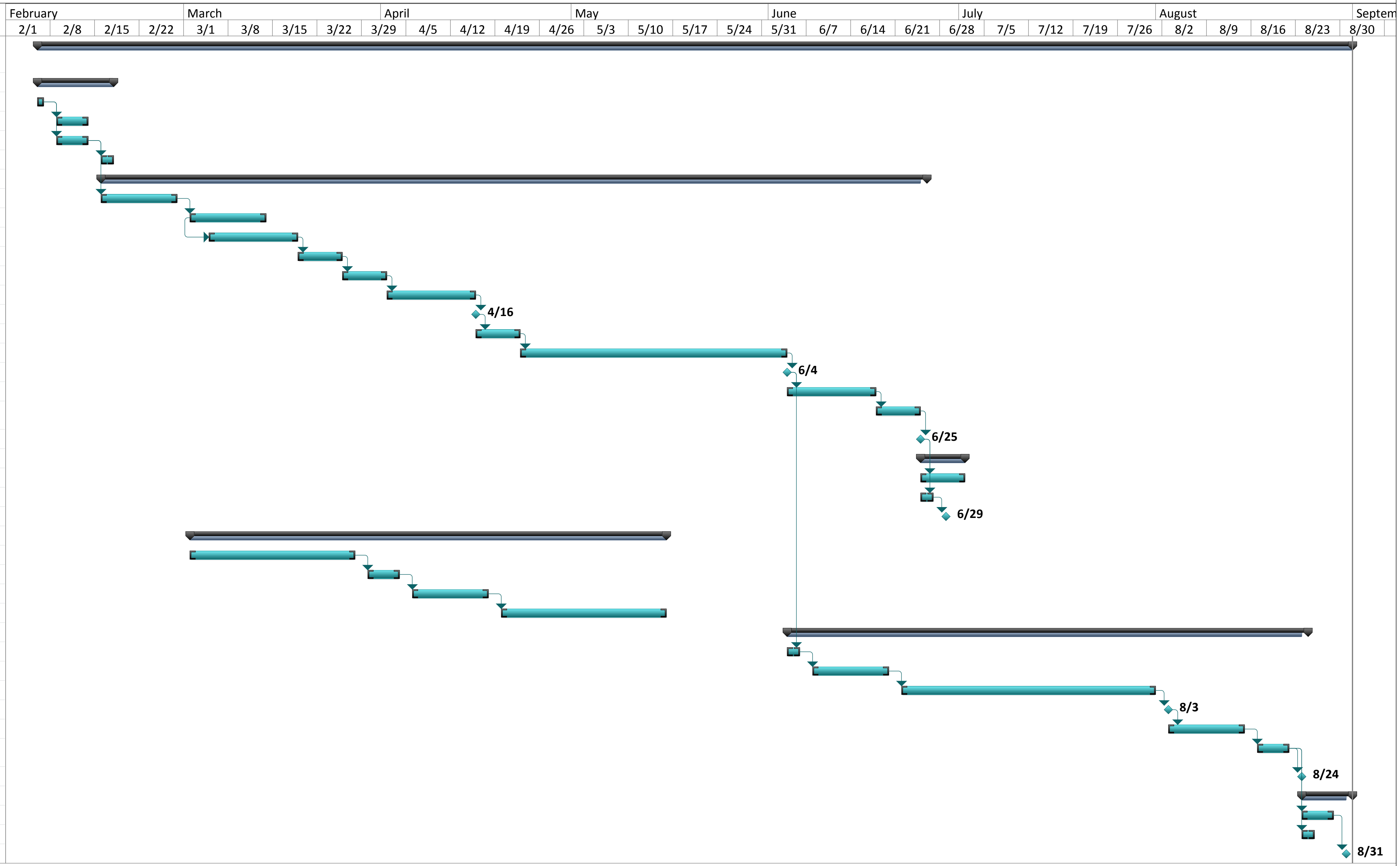


Proposed Schedule

Sanborn is one of the few firms in the mapping business that has the ability to manipulate large volumes of digital data, which results in quicker turnaround times from acquisition to finished product. Investment in IT infrastructure, qualified staff and a dedication to customer satisfaction is a priority across our corporation. Sanborn's draft schedule is shown on the following page in a Gantt chart.

COAGA 2015 Draft Schedule

ID	Duration	Start	Finish
1	**147 days**	**Fri 2/6/15**	**Mon 8/31/15**
2	**8 days**	**Fri 2/6/15**	**Tue 2/17/15**
3	1 day	Fri 2/6/15	Fri 2/6/15
4	5 days	Mon 2/9/15	Fri 2/13/15
5	5 days	Mon 2/9/15	Fri 2/13/15
6	2 days	Mon 2/16/15	Tue 2/17/15
7	**94 days**	**Mon 2/16/15**	**Thu 6/25/15**
8	10 days	Mon 2/16/15	Fri 2/27/15
9	10 days	Mon 3/2/15	Fri 3/13/15
10	10 days	Thu 3/5/15	Wed 3/18/15
11	5 days	Thu 3/19/15	Wed 3/25/15
12	5 days	Thu 3/26/15	Wed 4/1/15
13	10 days	Thu 4/2/15	Wed 4/15/15
14	0 days	Thu 4/16/15	Thu 4/16/15
15	5 days	Thu 4/16/15	Wed 4/22/15
16	30 days	Thu 4/23/15	Wed 6/3/15
17	0 days	Thu 6/4/15	Thu 6/4/15
18	10 days	Thu 6/4/15	Wed 6/17/15
19	5 days	Thu 6/18/15	Wed 6/24/15
20	0 days	Thu 6/25/15	Thu 6/25/15
21	**5 days**	**Thu 6/25/15**	**Wed 7/1/15**
22	5 days	Thu 6/25/15	Wed 7/1/15
23	2 days	Thu 6/25/15	Fri 6/26/15
24	0 days	Mon 6/29/15	Mon 6/29/15
25	**55 days**	**Mon 3/2/15**	**Fri 5/15/15**
26	20 days	Mon 3/2/15	Fri 3/27/15
27	5 days	Mon 3/30/15	Fri 4/3/15
28	10 days	Mon 4/6/15	Fri 4/17/15
29	20 days	Mon 4/20/15	Fri 5/15/15
30	**58 days**	**Thu 6/4/15**	**Mon 8/24/15**
31	2 days	Thu 6/4/15	Fri 6/5/15
32	10 days	Mon 6/8/15	Fri 6/19/15
33	30 days	Mon 6/22/15	Fri 7/31/15
34	0 days	Mon 8/3/15	Mon 8/3/15
35	10 days	Mon 8/3/15	Fri 8/14/15
36	5 days	Mon 8/17/15	Fri 8/21/15
37	0 days	Mon 8/24/15	Mon 8/24/15
38	**6 days**	**Mon 8/24/15**	**Mon 8/31/15**
39	5 days	Mon 8/24/15	Fri 8/28/15
40	2 days	Mon 8/24/15	Tue 8/25/15
41	0 days	Mon 8/31/15	Mon 8/31/15



Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

Relevant Experience

Sanborn has a demonstrable track record of success on large, complex orthoimagery, LiDAR and photogrammetric mapping projects throughout the United States. The company's experience includes many orthoimagery and mapping projects throughout the Midwest and Southeast Region. Representative projects that demonstrate Sanborn's ability to deliver projects of this size, scope, and complexity are provided on the following pages, including contact information.

Reference:
Pikes Peak Geospatial Alliance, Colorado

Sanborn was selected by the Pikes Peak Geospatial Alliance (PPGA) in the Spring of 2007 to provide digital orthoimagery covering 3 counties. The PPGA consists of multiple agencies including the City of Colorado Springs, El Paso County, Teller County, E911, and four military installations. Since 2008, Sanborn has completed LiDAR flights within the Colorado Springs region for Colorado Springs Utilities (CSU) and the Pikes Peak Geospatial Alliance. Sanborn's current contract was awarded in 2011, and two option years have been exercised.

Contact Name	**Mike Herrmann**
Phone / Fax	(719) 668-8369 / (719) 668-5329
Email	MHerrmann@csu.org
Customer Name	**Pikes Peak Geospatial Alliance (PPGA)**
Address	111 S. Cascade Avenue Colorado Springs, CO 80903
Project Term	March 2007 – March 2014
Project Value	$456,458 (2007) $149,543 (2009) $532,630 (2011)
Project Area	2,890 square miles (2007) 2,226 square miles (2009) 2,261 square miles (2011)

Project Scope

Sanborn was selected by the PPGA in the Spring of 2007 to provide 2,890 square miles of digital orthoimagery, covering 3 counties. The PPGA contracted with Sanborn again in 2009 to provide 2,226 square miles of 1-foot orthoimagery over Colorado Springs, El Paso County and Woodland Park in Teller County. The imagery was acquired in summer of 2010 and the project was completed on schedule in spring 2011.

The scope of work included the utilization of digital camera technology for 338 square mile of 0.5-foot resolution imagery within the City of Colorado Springs, and 2,552 square miles of 1-foot resolution imagery within El Paso County and Teller County encompassing Pike National Forest. The terrain variance extends from 5,000-feet above sea level to over 14,000 feet in elevation. Sanborn delivered 4-band orthoimagery and updated Digital Elevation models. Sanborn provided separate leaf-on color infrared (CIR) 0.5-foot resolution orthoimagery dataset for the 338 square miles of the City of Colorado Springs.

Sanborn has completed additional LiDAR, Digital Orthoimagery and DEM update projects, including the following, for the PPGA:

- Pikes Peak Geospatial Alliance: Sanborn collected 2,000 square miles of LiDAR and imagery data of El Paso County in 2011. The project area contains terrain variances of over 8,000 feet. Further, breakline hydro enforcement was required for specific drainages throughout the County which exceed USGS specifications. The LiDAR data was collected at a density of 1.4-meters and supported a 15cm RMSE accuracy. Sanborn produced derived products that included 2-foot contour lines, arcGRID DEMs and final DTMs with breaklines for hydro enforcement. Sanborn collected 20 check points and produced a NSSDA report for accuracy assessment.
- Monument Creek Waldo Fire Emergency Response: After the Waldo Canyon Fire in 2012, erosion exposed a major pipeline carrying water from Rampart Reservoir to the City. Sanborn collected 8 pts/m2 density LiDAR, for CSU to assess the damage and calculate the metric ton of material needed to fill the exposed area. Data was captured and delivered within a 1-week timeframe.
- Southern Delivery System Pipeline Analysis: In 2012 Sanborn completed a corridor of LiDAR collection. The data was used to assess change to the terrain from pre- to post-pipeline status. Data accuracy and density supported 1-foot contours and a 9.25cm RMSE. Data was captured and delivered within a 2 week schedule.
- Sanborn was commissioned to complete two independent LiDAR acquisitions over the urban area of Colorado Springs for 3-D modeling purposes. The LiDAR flight was completed with multiple perpendicular flight lines allowing for the elimination of LiDAR "shadows" caused by buildings. The second LiDAR acquisition was completed at the top of Hoosier Pass for portions of Park and Summit County. Careful flight planning, ground control selection, and acquisition procedures were needed to ensure the data continued no voids, the density of points allowed for 2-foot and 4-foot terrain modeling, and the overall data met accuracy expectations.

Reference:
Michigan Statewide Orthoimagery Program

Sanborn was selected to provide a statewide digital orthoimagery collection program of 6-inch GSD and 12-inch GSD Imagery covering the entire state of Michigan every 3 to 5 years. Imagery must be leaf-off, snow free, cloudless and adhere to 1"=100' map scale accuracy standards.

Contact Name	**Everett Root** Office of Technology Partnerships
Phone	517-373-7910
Email	roote@michigan.gov
Customer Name	**Michigan Department of Technology and Budgets (DTMB)**
Address	Lewis Cass Building, 2nd Floor 320 S. Walnut Street P.O. Box 30026 Lansing, MI 48909
Project Term	March 2013 – September 2015 with 2-year option.
Project Value	~$5,000,000

Project Background

In the spring of 2013, the state of Michigan contracted with Sanborn to continue a program to acquire, process, and deliver orthoimagery for the entire state on a rolling basis, delivering new imagery for each county every 3 to 5 years. This program involves the production of 1-foot digital orthophotography to meet a mapping specification for 1"=100' scale as well as many jurisdictions enhancing the data to 6-inch resolution for a mapping specification of 1"=100' scale or QL2 or QL3 LiDAR data collection to support modeling efforts. As of 2014, several local jurisdictions are also exploring adding oblique imagery and 3-inch digital imagery to their buy-ups.

Project Scope

Sanborn is responsible for the acquisition of imagery/LiDAR, placement of ground control/checkpoints, aerial triangulation, manual stereo-compilation of masspoints, and breaklines to produce a new Digital Terrain Model (DTM) throughout the entire State to support either 1-foot or 6-inch digital orthophotography. For LiDAR data collection, each participant has the option to buy up to products such as hydro-enforced breaklines, hydro flattened water features, and additional point cloud classifications. All options are built into a detailed pricing structure that is agreed to prior to each acquisition season.

Reference:
State of Louisiana

In December of 2013, Sanborn was selected by the State of Louisiana to provide updates to their statewide orthoimagery program. This project consisted of 3,581 square miles of imagery collected and processed at 6-inch, 4-inch and 3-inch resolutions.

Contact Name	**Brant Mitchell,** Research & Operations Stevenson Disaster Management Institute
Phone	(225) 578-5939
Email	Bmitch9@lsu.edu
Customer Name	**Governor's Office for Homeland Security and Emergency Preparedness, (GOHSEP)**
Address	7667 Independence Blvd Baton Rouge, LA 70806
Project Term	December 2013—December 2014
Project Value	$653,883.29
Project Area	3,581 square miles

Project Background

Sanborn was selected by Louisiana's Governor's Office for Homeland Security and Emergency Preparedness (GOHSEP) to conduct an update to the statewide imagery collected in a previous statewide program in 2010. The purpose of the program was to collect digital imagery at a higher resolution than the previous statewide program in critical areas. Sanborn collected, processed and delivered the imagery in accordance with stakeholder needs.

Project Scope

Sanborn was responsible for all aspects of production, from data acquisition, ground control and AT, through development of DEM, image rectification, mosaicking and final orthophoto tile extractions.

Sanborn supplied the aircraft and sensors, and was responsible for managing a team of pilots, operators, and surveyors. The remainder of the scope of work was accomplished at Sanborn's Colorado Springs facility and using Sanborn's offshore imagery production partner.

Project Statistics:

- 2,229 square miles of 4-inch GSD Imagery
- 375 square miles of 3-inch GSD Imagery
- 537 square miles of 6-inch GSD Imagery

Technical Specifications	
Aerial Photography	▪ Accomplished with Microsoft UltraCam Eagle sensors coupled with IMU/GPS systems to provide photo-center control
Image Processing	▪ 3-inch, 4-inch and 6-inch orthophotography meeting ASPRS Class 1 horizontal accuracy standards for 100 and 400 scale orthophotography
Ground Control Survey	▪ Sanborn ground survey and paneling
Orthophotography	▪ Final output in UTM NAD 83 15N projection, meters, 4-band, 8-bit TIFF/TFW output on the LA6KGRID (1/4 DOQQs)
Surface	▪ LiDAR DEM developed for the statewide program in 2010

Staffing

Sanborn's experience with and ability to manage complex multi-jurisdictional orthoimagery and LiDAR programs is due in no small part to significant investments in human resources. The Sanborn team of over 125 geospatial technology and management professionals possesses an enviable resume of project experience, significant educational credentials, and registration from government agencies and leading industry associations. Sanborn offers COAGA 2015 an exceptionally qualified project team with many years of experience in digital orthoimagery production.

Sanborn employs some of the most talented and dedicated individuals in the mapping industry. Our highly trained staff includes certified photogrammetrists, LiDAR experts, registered land surveyors, survey technicians, pilots, aerial photographers, photo lab technicians, cartographers, photo interpreters, stereocompilers, CADD technicians, image processing specialists, computer programmers, and GIS design professionals. Their vast experience and close attention to detail ensures that the most effective aerial photography and digital mapping solutions are developed in a cost-effective manner.

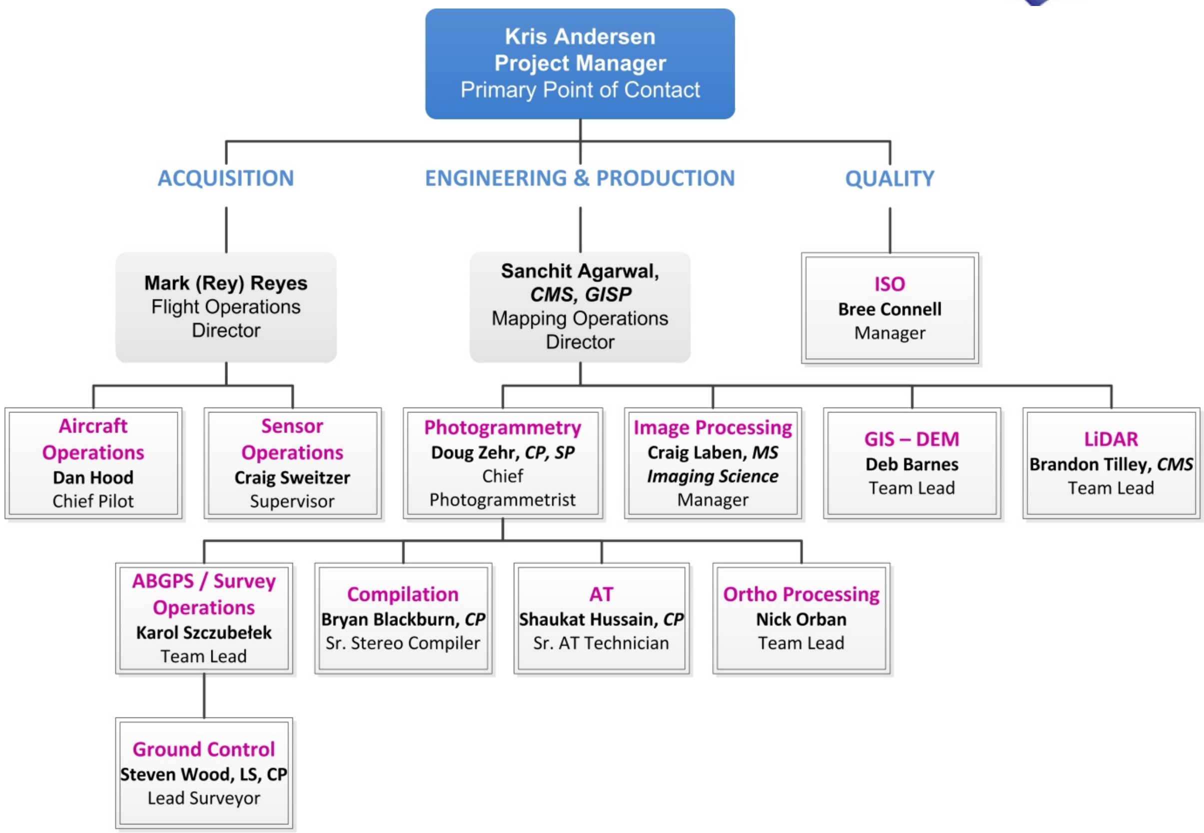
Key Personnel

Sanborn uses established, cohesive teams that streamline the production process significantly. Under this approach the project benefits from the synergy of a proven team, which is critical to achieving maximum efficiency for cost-effective solutions. Sanborn's staffing structure ensures that project requirements are met. We select project team members based on the following criteria:

- Goals of COAGA 2015
- Project management experience
- Reliability in meeting schedules
- Technical expertise
- Commitment to quality

COAGA 2015's project will be completed out of our main production facility and corporate headquarters located in Colorado Springs, Colorado. The technical managers and production staff all work together in a single facility, which creates the ideal conditions for effective communication and productive workflows. Also of note, we have several Certified Photogrammetrists on staff, which will help ensure the COAGA 2015's products conform to the required mapping standards.

The following organizational chart highlights key project personnel and their expertise.



Program Participation

Each project is assigned a project manager with responsibilities including customer communication, scheduling, and ensuring adherence to the project specifications. The project manager works with department managers and production staff in establishing an implementation plan that outlines the project's technical requirements. The department managers draw on their production staff, as required, to meet the project objectives. The specific list of employees involved in any given project can be extensive with up to 25 employees or more, depending on the project size and schedule.

The following table illustrates the percentage of time overall that this project is expected to represent for our proposed Key Personnel.

Essential Staff Roles and Participation		
Name	**Role**	**Percent Project Commitment**
Kris Andersen	Project Manager	5%
Sanchit Agarwal	Mapping Operations Director	10%
Rey Reyes	Flight Operations Director	50% (during acquisition)
Craig Sweitzer	Sensor Operations Supervisor	50% (during acquisition)
Doug Zehr	Chief Photogrammetrist	15%
Nick Orban	Ortho Team Lead	70% (during orthoimagery production time)
Craig Laben	Imaging Processing Manager	10%
Bryan Blackburn	Sr. Stereo Compiler	50% (during production timeframe)

Project Management

Sanborn's Project Manager for the COAGA 2015's program will be **Mr. Kris Andersen**. Mr. Andersen has over 15 years of experience managing Geospatial programs, including statewide collections for Michigan and Louisiana as well as large programs for Maricopa County, AZ; the Southern Nevada Water Authority; Pima Association of Governments, AZ; and the Southern California Council of Governments. Mr. Andersen has extensive experience in managing all phases of imagery and mapping projects, and as project manager, he has had direct accountability for advanced project design, program financial design and management, program execution, risk management, and schedule management. Mr. Andersen is trained in Agile Delivery Methodologies and uses the latest collaboration tools to ensure all program stakeholders are kept informed on Program progress.

Mapping Operations Director

Mr. Sanchit Agarwal, CP, CMS, GISP, is Sanborn's Mapping Operations and Quality Director. Mr. Agarwal has over nine years of experience in the field of Geo-informatics. He is proficient in both production and research & development working environments and has in-depth knowledge of GIS technologies, Aerial Triangulation; GPS-IMU processing; LiDAR data processing; Digital Imaging; Flight Planning; DEM editing and RADAR data processing. He has experience in handling data from multiple sensor platforms: aerial/terrestrial; push-broom/frame sensors; panoramic/oblique imaging systems; and LiDAR/RADAR systems. He has excellent skills in managing large scale projects in production environment and a proven ability to train & develop production teams for new technologies. Mr. Agarwal, an ASPRS Certified Photogrammetrist, will monitor compliance and manage the engineering and quality for the COAGA 2015's program.

Acquisition

Mr. Reyes has more than 20 years in the Aviation and Logistics industries and more than 10 years of experience in Program Management and Strategic Planning. He joined Sanborn in 2014 and previously served as a career Naval Aviator, flying fighter aircraft from aircraft carriers during multiple combat deployments. Since joining Sanborn, he has had notable success directing a broad range of aircraft and sensor initiatives; participating in planning, analysis, and implementation of solutions in support of business objectives. Mr. Reyes has extensive experience working with executives at all levels of the government to implement the collection of spatial technologies.

Mr. Craig Sweitzer has more than 13 years' experience in Aerial and GPS survey, with deep knowledge in all data acquisition operations that Sanborn performs. Currently, he supervises and coordinates the activities and personnel of the Acquisition Operations department that involve collection of data for aerial imagery, aerial LiDAR and GPS checkpoint location, ensuring production and quality standards are met; and, is responsible for training for all imaging sensors that Sanborn currently owns and operates. Mr. Sweitzer is also involved in all facets of sensor maintenance and operation. He operates, installs, and is trained on all Sanborn sensors including the LiDAR sensor Leica ALS70, and the digital Cameras UltraCam Eagle, UltraCam D and Intergraph DMC. Mr. Sweitzer He has been involved in the majority of all collection projects both large- and small-scale over the last several years for Sanborn. Mr. Sweitzer has developed and documented procedures and processes for all Sanborn camera sensors and has been instrumental in the development of LiDAR procedures and processes.

Mr. Daniel Hood has 40 years of experience in aviation management and as a pilot, both in Alaska and the contiguous US. Prior to joining Sanborn, Mr. Hood gained extensive experience flying digital imagery and LiDAR acquisition missions. Mr. Hood brings over 30,000 hours of total pilot time, and a verifiable perfect safety record. He is competent and knowledgeable in flight operations management, with specific expertise in medium and large aircraft with digital and integrated avionics.

Photogrammetry

Mr. Doug Zehr, CP, SP, has 27 years of industry experience and is a member of Sanborn's photogrammetric management team. His responsibilities include project planning and design, overseeing aerial triangulation, and the support of photogrammetric and LiDAR production processes.

Mr. Karol Szczubełek has over 13 years of experience in geodetic surveying. As ABGPS Team Lead, he is responsible for coordinating, processing and troubleshooting ABGPS data. Mr. Szczubełek has been actively involved in the geodetic surveying, aerial photography, and LiDAR data collection. He is responsible for implementing and establishing methods for maximizing accuracies of processing geodetic survey data with impressive results. He heads and supervises all surveying activities and survey applications development, including the planning, field coordination and processing of surveyed LiDAR checkpoints and aerial photo control points. Mr. Szczubełek is also responsible for documentation, training, and monitoring all QC/QA activities pertaining to geodetic surveying. He was in charge of coordination, execution, and reporting for a multi-year GPS survey project on several military bases throughout the country for the U.S. government.

Mr. Steven Wood*, Oklahoma registered Surveyor # X1116,* will perform and certify all ground control survey work to support the project requirements and accuracy specifications. Mr. Wood, who combines an extensive land surveying and civil engineering background with more than 42 years of project management experience in engineering, land development, surveying and photogrammetry, has developed several customized solutions for industry-leading photogrammetric projects. His surveying experience is comprehensive and includes many years of practical field assignments and office management of more than a dozen survey field crews. Projects include almost every type of surveying including land boundary, construction staking, flood insurance cross section surveys, ALTA minimum standard surveys, power plant layout, right of way takings, GPS control surveys for control densification and photo control projects, precise second order control surveys, differential and on the fly GPS field inventory of utilities, and Department of Defense GIS mapping and field inventory. Mr. Wood has also served as the Surveyor in Responsible Charge overseeing multi-participant municipal mapping and surveying projects for many countywide landbase mapping projects throughout the US and overseas. Mr. Wood has helped implement innovative surveying uses of current technology to accomplish timely and economical survey solutions throughout his career.

Imagery

Mr. Craig Laben has over 20 years of experience in remote sensing, GIS, image processing, geospatial analysis and geospatial product quality assurance. He has extensive knowledge of commercial and government satellite and aerial EO, MS, IR and radar imaging systems data and their applications. In addition, Mr. Laben has developed algorithms, techniques, processes and metrics to improve the image quality, accuracy and intelligence value of geospatial products. For all aerial projects within Sanborn's mapping operations, Mr. Laben coordinates activities between the flight acquisition team and the production team, and ensures that image quality and accuracy standards are met. Mr. Laben works with the GPS-IMU and Image Quality Control (QC) teams to optimize workflow and to develop more efficient processes, improving data ingest and QC processing times.

Orthoimagery Production

Mr. Nick Orban has more than 4 years of experience in the GIS industry with experience ranging from basic mapping techniques to advanced orthoimagery production and image processing. Over the last 4 years, Mr. Orban has expanded his skills into the realm of orthoimagery, image processing, and vector-based GIS. Using advanced analysis and project-based coordination, he and his team have successfully honed and streamlined the ortho process. He has also worked as a Senior Imaging Technician and Image Processing Technician for multiple projects and programs. As an Operations Team Lead, he is not only responsible for the execution, processing, and final deliverable generation for assigned ortho programs, he is involved in process development and troubleshooting. Mr. Orban's thorough understanding of each step in ortho and image processing production ensures programs are run effectively and efficiently.

Compilation

Mr. Bryan Blackburn is a Certified Photogrammetrist with over 25 years of experience in photogrammetry and conventional land surveying, including 16 years' experience in management. In addition to his role as Sr. Stereo Compiler for Sanborn, Mr. Blackburn is currently the Tennessee Councilperson for the Mid South Region of ASPRS (American Society of Photogrammetry and Remote Sensing). Mr. Blackburn has extensive experience in photogrammetry and computer technology related to the field of digital mapping, digital terrain modeling (DTM), orthophotography, model preparation, triangulation, and GIS databasing. He has been responsible for project scheduling, triangulation, production and management, initializing new projects, and training new personnel. Mr. Blackburn is proficient with Intergraph ImageStation, ISAT and Microstation.

LiDAR Production

Mr. Brandon Tilley, LiDAR Lead Technician will complete all LiDAR processing, classification, product development, and metadata development. Mr. Tilley has 7 years of experience in the GIS division with expertise in LiDAR production workflows, data processing, and a wide range of LiDAR products. He has worked as a LiDAR Analyst for numerous customers providing small and large scale products while meeting or surpassing clients' expectations. Mr. Tilley is responsible for implementing new and faster processes, as well as processing, product generation, problem solving, and quality assurance. Mr. Tilley's knowledge and experience creates a constructive environment and enables projects to be completed with the utmost quality and accuracy.

GIS Operations (Hydrological-Flattening)

Ms. Deborah Barnes has more than 15 years of experience in mapping and data development. She has served as Team Lead in GIS and Photogrammetry. As the GIS Team Lead, she is responsible for training and implementing tools to increase Sanborn's efficiency in meeting the USGS version 13 specifications for hydro production. Ms. Barnes has extensive experience in database management systems and spatial technologies on multiple hardware and software environments and the implementation of new technologies to improve end user productivity. As the GIS lead for CPE's program, Ms. Barnes will supervise the processing technicians and ensure the project adheres to schedule, quality and production standards.

Resumes

The following are resumes of Sanborn's proposed key personnel.

Kristopher Andersen

Project Manager

Mr. Andersen has more than 15 years of experience in systems integration, project management, and enterprise deployments, specializing in the integration of new and existing spatial technologies. He presently manages major Orthoimagery and LiDAR collection programs for Sanborn. Mr. Andersen previously served as Senior Project Manager/GIS Practice Leader specializing in Data Management, Conversion, and Deployment. Mr. Andersen has been trained in Agile Program Delivery as well as specializing in Traditional Program Delivery methodologies.

Education

- **Master of Arts, Geography**—University of Connecticut, Storrs, CT, 2002
- **Bachelor of Science, Geography**—James Madison University, Harrisonburg, VA, 1998

Affiliations and Certifications

- **Project Management Institute (PMI)**—member
- **Urban and Regional Information Systems Association (URISA)**—member

Project Experience

- **State of Michigan Department of Technology Management and Budget, November 2013–Present.** Mr. Andersen serves as the Program Manager for the statewide Orthophotography and LiDAR collection program held by Sanborn. Mr. Andersen is responsible for coordinating ground survey teams, pilot flights, data processing, QC, data delivery, schedule management and financial performance.
- **Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP), January 2014-Present.** Mr. Andersen serves as the Program Manager for a 3-inch, 4-inch and 6-inch GSD Imagery Program of the State's critical ports and infrastructure. Mr. Andersen is responsible for coordinating ground survey teams, pilot flights, data processing, QC, data delivery, schedule management and financial performance.
- **Southern Nevada Water Authority (SNWA), December 2013-Present.** Presently managing a yearly digital imagery collection project for the Water Resource Provider of Las Vegas. Project required coordination with local military installation to fly in secure airspace. Responsible for coordinating ground survey teams, pilot flights, data processing, QC, data delivery, schedule management and financial performance.

Publications / Presentations

- Roworth, Holloway, Andersen and Taylor, (2010, October). **"*ArcGIS for Water Infrastructure*,"** ESRI Podcast

- **City of Newport RI GIS update. October 2010-February 2013.** Coordinated the update of citywide GIS data using mobile devices, 2012 LiDAR data, and documents from various entities within the City, such as the US Navy.
- **Inner Doha Re-Sewerage Implementation Strategy (IDRIS). July 2012-December 2012.** Mr. Andersen managed the requirements gathering and document management for a public facing website demonstrating the benefits of the program as well as critical project updates and milestones.
- **Boston Water and Sewer Commission Drainage Basin Redelineation Project. October 2012-February 2013.** Mr. Andersen managed the creation of new drainage areas using 2009-10 LiDAR data and hydraulic modeling applications. The purpose was to assist the city with a comprehensive infrastructure improvement plan addressing excessive runoff into protected waterways near the city. Mr. Andersen was responsible for scope, schedule, technical documentation, and budget of the project.
- **Abu Dhabi Sewerage Services Company Strategic Tunnel Enhancement Programme. October 2008-January 2013.** Program Manager for the creation of digital media demonstrating the importance of the program, as well as critical project updates. Developed a public facing website and several media presentations shown to the public and influential leaders.
- **Metropolitan Washington Airports Authority Enterprise GIS System. February 2008-June 2011.** Mr. Andersen managed the creation of GIS Data derived from record drawings and aerial survey. The purpose of

this data creation was to populate an enterprise GIS system for Reagan and Dulles Airports for use by airport employees.

Work History

- **Program Manager, Sanborn, Colorado Springs, CO, November 2013—Present.** Mr. Andersen is responsible for the management of all activities within his project portfolio. This includes project planning, execution, QA/QC, delivery and financial performance.
- **Project Controls Specialist, MWH Global, Tucson, AZ, March 2013—September 2013.** Mr. Andersen managed financial forecasting, the master schedule, and invoicing for the largest infrastructure program underway in Arizona. This project ended in fall 2013.
- **Senior Project Manager/GIS Practice Lead, Critigen, Boston, MA, September 2009—March 2013.** Mr. Andersen was responsible for a portfolio of nearly 30 GIS projects as well as 20 GIS Professionals located in 6 offices in the Northeastern United States. Mr. Andersen was responsible for the performance of his projects as well as of his staff.

Sanchit Agarwal, CMS, GISP

Mapping Operations and Quality Director

Mr. Agarwal has over 9 years of experience in the field of geo-informatics. He is proficient in production, research and development environments. Mr. Agarwal's in-depth knowledge of GIS technologies includes Aerial Triangulation, GPS-IMU processing, LiDAR data processing, digital imaging, flight planning, DEM editing and RADAR data processing. He has experience in handling data from multiple sensor platforms, including aerial/terrestrial sensors, push-broom/frame sensors, panoramic/oblique imaging systems, and LiDAR/RADAR systems. He is adept in managing large scale production projects, with a proven ability to train and develop production teams for new technologies. Mr. Agarwal has facilitated requirement gathering and brainstorming sessions for process enhancement and automation, and has exceptional quantitative, analytical and problem solving skills.

Education

- **MS, Geomatics Engineering**—Ohio State University, Columbus, OH, 2006
- **B.Tech., Civil Engineering**—Indian Institute of Technology (BHU), Varanasi, India, 2003

Affiliations and Certifications

- **Certified Mapping Scientist (CMS)—** ASPRS, No. 223, 2010
- **GIS Professional (GISP)**—GIS Certification Institute, No. 64283, 2010

Computer Skills

- **Programming and Database**— VBA, MATLAB, SQL, Geodatabase, Database design and management
- **GIS and Remote Sensing**—ArcMap, ArcCatalog, ArcScene, ArcObjects, ArcToolbox, Map Info, GeoCue, SocetSet, TerraSolid products, MapInfo, MicroStation, ERDAS Imagine, QCoherent, GrafNav, PosPac

Publications / Presentations

- Agarwal, Sanchit. (2008, Sept). **“*Photogrammetric Processing of Rover Imagery of 2003 Mars Exploration Rover Mission*,”** ISPRS
- Agarwal, Sanchit. (2007, July). “***A WebGIS for Spatial Data Processing, Analysis & Distribution for the MER 2003 Mission***,” P&RS
- Agarwal, Sanchit. (2007, Apr). “***Rock Modeling & Matching for Autonomous Mars Rover Localization***,” Journal of Field Robotics

Project Experience

- **State of Louisiana, LA, November 2010–June 2012.** Mr. Agarwal managed the mapping production for the statewide aerial photography and orthophoto program, including attending customer meetings for assisting with any technical questions on quality, products and services.
- **New York Statewide Orthoimagery Program, NY, May 2010–Present.** Mr. Agarwal is managing the mapping production of orthoimagery at various resolutions and imagery types for more than 30,000 square miles in the State of New York. He is also responsible for the coordination of the mapping division production staff and liaison between operations and the project management team.
- **Virginia Base Mapping Program, VA, May 2010–Present.** Mr. Agarwal manages production and operations, including monitoring the program, tasks, staff, schedule and quality, and reporting conditions to upper management.
- **Gwinnett County, GA, May 2010–Present.** Orthoimagery, LiDAR, and Planimetric Mapping Program. Mr. Agarwal manages production and operations, including monitoring the program, tasks, staff, schedule and quality, and reporting conditions to upper management.
- **Pikes Peak Geospatial Alliance, CO, 2011–2012.** Pikes Peak Area Orthos and LiDAR Program. Mr. Agarwal managed the production and operations team within the mapping division to provide 2,890 square miles of digital orthoimagery over three counties in Colorado.

Work History

- **Mapping Operations and Quality Director, Sanborn, Colorado Springs, CO, January 2013–Present.** Mr. Agarwal monitors compliance and manages project engineering and quality. Mr. Agarwal works with the production team to optimize workflow and set up project processes according to specifications and priorities.
- **Mapping Operations Director, Sanborn, Colorado Springs, CO, February 2012–January 2013.** Mr. Agarwal led the production and operations management team within the mapping division. This responsibility included strategically directing and monitoring budget, schedule, staffing, workflows and training; acting as the

main liaison between the project management and operations staff for setting up the expectations and priorities; ensuring that proper procedures were in place and followed for delivering quality mapping products and services to customers; evaluating the latest technologies for potential implementation in the production processes; leading innovation, process improvement and workflow optimization efforts to gain efficiencies in the production procedures; attending customer meetings to assist with technical questions on quality, products and services; providing production feedback, metrics, insight and support to the proposal, sales and marketing team; and representing Sanborn at industry events.

- **Director of Technical Quality, Sanborn, Colorado Springs, CO, May 2010–February 2012.** Mr. Agarwal worked with the production team for workflow optimization and process improvement, resulting in better quality products at higher efficiencies. In addition, he analyzed the latest technologies for possible implementation in the production processes and conducted internal ISO audits.
- **Director Operations and Chief Technologist, HJW GeoSpatial Inc., Oakland, CA, September 2009–May 2010.** Mr. Agarwal led and managed the production and flight operation activities, executed the complete pre-processing and post-processing workflow of UltraCamX data, tested new technologies for possible new mapping products in the emerging markets, and worked with the sales and marketing team to broaden the portfolio of the products that the company offers to prospective customers.
- **Technical Lead, GeoSAR, Fugro EarthData Inc., Frederick, MD, November 2007–August 2009.** Mr. Agarwal held key responsibilities as lead for the successful delivery of multi-million dollar mapping projects, continuously monitored the projects to identify gaps in meeting the target, reported progress weekly and monthly to managers, accelerated execution of projects to drive faster realization of cost benefits, streamlined the existing workflows to achieve higher efficiency and better quality of GeoSAR products, facilitated the documentation of the GeoSAR processes to comply with the ISO requirements, conducted training sessions in the company, and deployed GeoSAR data processing capabilities at the Chinese division.
- **Senior Analyst, Technology Evaluation Group, Fugro EarthData Inc., Frederick, MD, June 2008–August 2009.** Mr. Agarwal was an active member of the technology evaluation group. He visited vendors to analyze new products and services to determine benefit to the portfolio of the company, conducted the feasibility and statistical analysis of the new technologies from the production viewpoint, and generated reports and delivered presentations that facilitated the decisions of management.
- **Subject Matter Expert & Trainer, QA/QC Procedures, Fugro EarthData Inc., Frederick, MD, June 2008–August 2009.** Mr. Agarwal functioned as subject matter expert on the formalized QA/QC procedures for the production processes and promoted the concept of internal independent review process. This process helped to catch any slips in the production and ensured first time right deliveries. Mr. Agarwal developed the tools and procedures for carrying out the independent review process, developed and maintained the ISO documentation for the QAQC procedures, and prepared training material and delivered training to production staff.
- **Senior AT Analyst, Fugro EarthData Inc., Frederick, MD, May 2006–August 2009.** Mr. Agarwal gained hands-on experience with end-to-end workflow of the Digital Mapping camera systems (ADS40) including flight-planning, GPS-IMU processing, aerial triangulation, orthophoto generation and DEM processing. Mr. Agarwal performed the complete pre-processing and post-processing workflow of the LiDAR (ALS50) data, worked extensively on GPS-IMU processing, boresite, feature extraction and surface-modeling of LiDAR data, played an instrumental role in optimizing the production workflows by customization and automation, and managed and delivered state-wide mapping projects on the production floor under tight deadlines.
- **Graduate Research Associate, Mapping & GIS Lab, Ohio State University, Columbus, OH, August 2004–May 2006.** Mr. Agarwal developed 3D terrain maps, slope maps and orthophotos of the Mars surface. These maps were used by the NASA scientists for safely navigating the rovers on the challenging Martian surface. Mr. Agarwal developed crater models by seamlessly integrating observations from multiple rover locations, and developed a model for the automation of on-board rover localization. This algorithm was designed to provide artificial intelligence to the rovers for auto-maneuvering in future robotic missions.

Rey Reyes

Director of Flight Operations

Mr. Reyes has more than 20 years in the Aviation and Logistics industries and more than 10 years of experience in Program Management and Strategic Planning. He joined Sanborn in 2014 and previously served as a career Naval Aviator, flying fighter aircraft from aircraft carriers during multiple combat deployments. Since joining Sanborn, he has had notable success directing a broad range of aircraft and sensor initiatives; participating in planning, analysis, and implementation of solutions in support of business objectives. Mr. Reyes has extensive experience working with executives at all levels of the government to implement the collection of spatial technologies.

Education

- **Master of Business Administration (MBA), Finance**—University of Colorado, 2010
- **Master of Arts, National Security and Strategic Studies**—U.S. Naval War College, 2007
- **Bachelor of Science, Mechanical Engineering**—U.S. Naval Academy, 1993

Affiliations and Certifications

- **Supply Chain Management**—National Defense University, 2013
- **Strategic Planner (Level III)—**U.S. Northern Command—2008
- **Aviation Safety—**U.S. Naval Safety Center—2002
- **Airline Transport Pilot—**Federal Aviation Administration—2002

Project Experience

Department of Defense (DOD) Lead Strategic Planner

- **U.S. Central Command, Tampa, Florida, July 2011–April 2014.** Mr. Reyes served as the project lead for the deployment, sustainment, and redeployment of all US forces in the support of the wars in Iraq and Afghanistan. He developed air, surface and maritime logistics solutions to ensure national security objectives were met while minimizing cost.
- **U.S. European Command, Stuttgart, Germany, May 2013-April 2014.** Mr. Reyes developed the DOD strategic plan for the elimination of Syria's chemical weapons, including mission analysis, course of action development, costing and budgeting, and mission execution resulting in the removal and neutralization of tons of Sarin, VX, and mustard agents at sea.

Work History

- **Director of Flight Operations, Sanborn Map Co, Colorado Springs, CO, Dec 2014—Present.** Mr. Reyes is responsible for the management of all Sanborn aircraft, pilot, sensor, and sensor operator activities, including strategic planning, budgeting, and collection execution.
- **Lead Classified Logistics Planner, U.S. Transportation Command, Belleville, IL, July 2011—April 2014.** Mr. Reyes was responsible for the management of all DOD logistic activities, including maritime, aviation, and surface for the Middle East, Europe, Russia and Africa.
- **Lead Classified Strategic Planner, U.S. Northern Command, Colorado Springs, CO, August 2007—June 2011.** Mr. Reyes was responsible for the management of all classified planning activities for the U.S. and Canada, including Continuity of Operations, Ballistic Missile Defense, and National Security.

Awards/Presentations

- Winner of CEO's Innovation Showcase Award in 2013 for process innovation, customer service improvement, leadership and team building

Craig Sweitzer

Data Acquisition Supervisor

Mr. Sweitzer is involved in all facets of sensor operation and has more than 12 years of experience assisting in GPS survey and data acquisition activities. He plans flights, operates, installs, and is trained on all Sanborn sensors including the Vexcel UltraCam D, X, and Xp; the Vexcel UltraCam Eagle digital camera; the Intergraph DMC digital camera; the MIDAS Oblique camera system; the Leica ALS50 LiDAR sensor; and, the Optech ALTM 2050 LiDAR sensor. Mr. Sweitzer is responsible for conducting training for all Sanborn's imaging sensors. He has been involved in the majority of collection projects both large and small scale. Mr. Sweitzer has developed and documented procedures and processes for the Sanborn camera sensors and has been instrumental in the development of LiDAR procedures and processes. He is a valued asset to Sanborn's data acquisition and surveying team.

Education

- **BS, Geography**—University of Regina, Regina, SK, Canada, 1998
- **Associate, Survey and Mapping Technology**—Southern Alberta Institute of Technology, Calgary, AB, Canada, 2001

Professional Education and Seminars

- Vexcel UltraCam, manufacturer's training
- Vexcel UltraCam, advanced maintenance training
- RC-30 Camera operations, manufacturer's training
- Optech ALTM operations, manufacturer's training
- Leica Geosystems ALS50, manufacturer's training
- Yearly sensor operation and field procedures and processing internal training
- GPS and Photography Survey, internal training
- ZI Digital Mapping Camera, manufacturer's training
- Track'Air Flight Management System, manufacturer's training
- Track'Air MIDAS Oblique Camera System, manufacturer's training.
- Applanix POS-AV manufacturer's training

Project Experience

- **Oblique Imagery Program, Customer Confidential, Multiple Cities, October 2012–Present.** Installs and operates MIDAS oblique camera systems, as well as oversees other camera operators and the data collection field processing operations.
- **Saskatchewan Province Orthoimagery Program, Saskatchewan, Canada, April 2012–Present.** In addition to operating the camera, he oversees other camera operators and the data collection field processing operations.
- **Qatar Petroleum Aerial Photogrammetry–Based GIS Database Updating Program, Qatar, March 2013–June 2013.** Installed and operated DMC camera and assisted with ground control surveys throughout Qatar.
- **Columbia Power Plant, Columbia, WA, June 2013.** Mr. Sweitzer collected and processed LiDAR and imagery data, and performed the field quality control procedures.
- **GEOSYS LiDAR Program, Northwest Territories, Canada, August 2013.** In addition to collecting ground survey data, Mr. Sweitzer collected and processed LiDAR data and performed the field quality control procedures.
- **New York State Digital Orthoimagery Program, NY, 2008–Present.** In addition to operating the camera, he oversees other camera operators and the data collection field processing operations.
- **Virginia Base Mapping Program, VA, 2007–Present.** In addition to operating the camera, he oversees other camera operators and the data collection field processing operations.
- **Louisiana Statewide, LA, February 2010–Present.** In addition to operating the camera, he oversees other camera operators and the data collection field processing operations.
- **Maricopa County, AZ, 2009–Present.** In addition to operating the camera, he oversees other camera operators and the data collection field processing operations.

- **National Agriculture Imagery Program, U.S. Department of Agriculture, Multiple States, 2004–2009.** In addition to operating the camera, he oversaw other camera operators and the data collection field processing operations.
- **City of Dubai, United Arab Emirates, 2005.** In addition to operating the camera, he supervised installation and operation of the sensor systems with foreign aircraft and airspaces.

Work History

- **Data Acquisition Supervisor, Sanborn, Colorado Springs, CO, August 2013—Present**. Supervises and coordinates activities and personnel in acquisition of data for aerial and satellite imagery, ensuring production and quality standards are met. Performs production work in these areas as required.
- **Operations Coordinator, Sanborn, Colorado Springs, CO, October 2008–August 2013.** Responsibilities same as below, and additionally was responsible for all mission planning and project tracking as well as managing all imaging field staff.
- **Senior Geodetic Technologist, Sanborn, Colorado Springs, CO, May 2001–September 2008.** Mr. Sweitzer's years of experience include aerotriangulation, geodetic surveying, GPS RTK surveying; analog photography (RC-30); Vexcel UltraCam-D installation, operation and maintenance; DMC camera installation, operation and troubleshooting; LiDAR collection; and Team Lead for several sensor collections.

Doug Zehr, CP, SP

Aerial Triangulation Manager

Mr. Zehr has 27 years of industry experience and is a member of Sanborn's photogrammetric management team. His responsibilities include project planning and design, overseeing aerial triangulation, and the support of photogrammetric and LiDAR production processes. He also works with Sanborn's business development group designing production and cost strategy.

Project Experience

- **Florida Power & Light, Utility Mapping, FL, March 2013—October 2013.** Color ortho and oblique imagery to support mapping of 1600 miles of transmission lines. Performed image QC, ortho and oblique production for PLSCADD model delivery.
- **Entergy, Utility Mapping, August 2012—March 2013.** Color ortho and oblique imagery to support mapping of 6000 miles of transmission lines. Developed workflow for image QC, ortho and oblique production to meet specific client requirements.
- **Maricopa County Orthophotos, Maricopa County, AZ, November 2007—Ongoing.** Color and NIR digital imagery collected at 0.32', 0.5', and 0.8' resolutions for a total of 27,000 images. Performed image acquisition, GPS surveys, AT, DTM update, and orthophotography.
- **Virginia Base Mapping Program (VBMP), VA, April 2009—Ongoing.** Statewide orthophoto and DTM mapping program involving aerial photography collection, GPS surveys, AT, compilation, and orthophoto generation. Total images 35,000 (eastern half of state).
- **Virginia Base Mapping Program (VBMP), VA, April 2007—February 2008.** Statewide orthophoto and DTM mapping program involving aerial photography collection, GPS surveys, AT, compilation, and orthophoto generation. Total images 47,000.
- **Pikes Peak Area Orthophotos, Colorado Springs Utilities, Colorado Springs, CO, April 2009—December 2009.** Color and NIR digital imagery collected at 0.5-foot and 1-foot resolutions for 3,000 square miles. Performed image acquisition, GPS surveys, AT, DTM update, and orthophotography.

Education

- **Graduate Studies, Geography, Physical Geography/Cartography**—Ball State University, Muncie, IN, 1986
- **BS, Earth-Space Sciences/Math**—University of Indianapolis, Indianapolis, IN, 1984

Affiliations and Certifications

- **Certified Photogrammetrist (CP)**—American Society for Photogrammetry and Remote Sensing (ASPRS), No. R1021, 1997
- **Surveyor Photogrammetrist (SP)**—Virginia, No. 0408000061, 2009
- **ASPRS**—Member, 1987
- **North Carolina Linux Users Group (NCLUG)**—Member, 2013

Continuing Education and Seminars

- Photogrammetric Processing Workshop, ASPRS Webinar, 2013
- Assessing Accuracy of GID Workshop, ASPRS Conference, San Antonio, TX, 2009
- Intro to Open Source Workshop, ASPRS Conference, San Antonio, TX, 2009
- Automated Linear Feature Extraction Workshop, ASPRS Conference, Portland, OR, 2008
- Image Enhancement Workshop, ASPRS Conference, Portland, OR, 2008
- Professional Airborne Digital Mapping System Workshop, ASPRS Conference, San Antonio, TX, 2006
- LiDAR Workshop, ASPRS Conference, Charleston, SC, 2004
- IMU Workshop, ASPRS Conference, Washington, DC, 2002
- Windows 2000 Server Training Course, Washington, DC, 2002
- LiDAR Workshop, ASPRS Conference, Washington, DC, 2000
- LiDAR Realm Training, Optech, Toronto, Canada, 1999
- Orthophoto Training, Intergraph, Madison, AL, 1992

Work History

- **Chief Photogrammetrist/AT Manager, Sanborn, Colorado Springs, CO, 2014—Present.** Mr. Zehr manages aerial triangulation operations, and works with a team to support workflow for Sanborn's large-format digital cameras and medium-format oblique sensors. As project designer, he works closely with the business development team and estimator to ensure technical questions, concerns, and strategies are disclosed and discussed. Mr. Zehr performs evaluation of software for production and works with development teams on strategies for process improvement.

- **Production Manager, McKim & Creed, Raleigh, NC, 2012—2014.** As production manager, Mr. Zehr established workflow and managed photogrammetric production for utility mapping programs. He worked closely with the regional manager on estimating, budget management, and scheduling, and provided customers with innovative technical solutions to satisfy needs utilizing existing datasets. Mr. Zehr was responsible for developing production workflows utilizing MIDAS RGB/IR sensors, Harrier 68i RGB sensors and VI Nadir RGB/IR and oblique sensors. This included field and office image processing, QC procedures, AGPS/IMU processing, orthophoto production, and delivery of nadir and oblique imagery in specific projections and formats. He resolved MIDAS sensor orientation issues allowing multiple offices (multiple software packages) to join production efforts.

Publications / Presentations

- Zehr, Doug. (2004, Aug). ***"Softcopy AT,"*** Geospatial Symposium, San Antonio, TX
- Zehr, Doug. (2002, May). ***"Ortho Production Techniques,"*** Alabama Association of Assessing Officials (AAAO), Muscle Shoals, AL

- **Aerial Triangulation Manager, Sanborn, Colorado Springs, CO, 2010—2012.** Mr. Zehr managed aerial triangulation operations, and worked with a team to support workflow for Sanborn's nine large-format digital cameras and facilitate data integration with LiDAR and photogrammetric sensors. As project designer/estimator, he worked closely with the business development team and project managers to ensure technical questions, concerns, and strategies were disclosed and discussed. Mr. Zehr consulted with project managers to ensure all projects' technical specifications were correct and complete. He also participated in proposal meetings to discuss project specifications and to present alternate strategies when appropriate.
- **Photogrammetric Department Manager and Photogrammetric Engineer, Sanborn, Colorado Springs, CO, 2006—2010.** Mr. Zehr led aerial triangulation and compilation operations. In addition, he worked with a team to support workflow for Sanborn's six large-format digital cameras and facilitate data integration with LiDAR and photogrammetric sensors. As project designer/estimator, he worked closely with the business development team and project managers to ensure technical questions, concerns, and strategies were disclosed and discussed. Mr. Zehr worked on the design of specifications for the standardization of select products, and consulted with project managers to ensure all projects' technical specifications were correct and complete. He participated in proposal meetings to discuss project specifications and to present alternate strategies when appropriate.
- **Chief Photogrammetrist/Photogrammetry Department Manager, Atlantic Technologies, Huntsville, AL, 1999—2006.** Mr. Zehr incorporated IMU technology with film cameras. He served as project manager of IMU bore sight. Tasks included project design and specifications, AT measurement and adjustment, and evaluation and analysis of resulting data. Responsible for establishing and supporting LiDAR integration within the photogrammetric workflow with input on accuracy standards, data collection routines, and automation. Assisted in establishing production procedures, quality assurance steps, and accuracy standards. Trained and supervised technicians. Provided AT adjustments of projects ranging from 5–3,000 images using Z/I and BINGO software.
- **Production/Project Manager, Atlantic Technologies, Indianapolis, IN, 1990—1999.** Mr. Zehr managed and supported photogrammetric and GIS mapping; maintained hardware and software proficiency, working with vendors and internal IT department to ensure PC and UNIX systems operated as designed; managed data archiving program, implementing digital tracking system for more effective retrieval; developed workflows to integrate film-based techniques with softcopy technology in AT and stereo compilation areas; managed production personnel (training and evaluations); consulted on marketing, estimating, project design, review, and evaluation of specifications and quality control; and managed 1"=50' engineering scale: 1' contour mapping, county-wide mapping with digital orthos, and GIS mapping projects. Mr. Zehr was also responsible for project design and execution.

Nicholas Orban

Ortho Operations Team Lead

Mr. Orban has more than 4 years of experience in the GIS industry with experience ranging from basic mapping techniques to advanced orthoimagery production and image processing. Over the last 4 years, Mr. Orban has expanded his skills into the realm of orthoimagery, image processing, and vector-based GIS. Using advanced analysis and project-based coordination, he and his team have successfully honed and streamlined the ortho process. He has also worked as a Senior Imaging Technician and Image Processing Technician for multiple projects and programs. As an Operations Team Lead, he is not only responsible for the execution, processing, and final deliverable generation for assigned ortho programs, he is involved in process development and troubleshooting. Mr. Orban's thorough understanding of each step in ortho and image processing production ensures programs are run effectively and efficiently.

Education

- **MGIS, emphasis in Remote Sensing & Image Analysis**—University of Central Arkansas, Conway, AR, Pending (2015)
- **Graduate GIS Certificate** —University of Central Arkansas, AR, 2010
- **BA, Geography & Environmental Studies**—University of Colorado, Colorado Springs, CO, 2009

Project Experience

- **McLean County Regional GIS Consortium, IL, April 2014—October 2014.** Mr. Orban served as the project lead in the McLean County imagery project held by Sanborn. He worked with the project managers to take the imagery from a raw product to process, color balance, QA/QC, edit, and arrange the specific deliverables on the project. This project has been delivered, meeting or exceeding the client's expectations in regards to early delivery and higher accuracy.
- **Appomattox River Water Authority, Lake Chesdin, VA, April 2014—August 2014.** Responsible for organizing, executing, and delivering this project. It has been delivered, meeting or exceeding the client's expectations in regards to early delivery and higher accuracy.
- **Province of Saskatchewan, Canada, December 2012—Present.** Performs project setup and design, reviews all images prior to delivering the products to the quality control department, ensures images are compliant with project specifications and quality standards, and develops project documentation and checklists.
- **Qatar Petroleum, Qatar, February 2013—Present.** Responsible for providing an ortho data set. Processing, QA/QC, and editing of the image data sets.
- **New York State Digital Orthoimagery Program, NY, 2010—2013.** Responsible for providing a highly detailed true-ortho data set. Mr. Orban worked on processing, QA/QC, and editing of the image data sets.

Work History

- **Operations Team Lead, Sanborn, Colorado Springs, CO, December 2012—Present.** Mr. Orban is responsible for the productions activities within Sanborn's Mapping Division. He is responsible for the oversight and end-to-end success of multiple projects in the ortho department, in addition to the input and processing of raw data on Sanborn's image processing side. Along with the duties of the project coordinator, Mr. Orban's other responsibilities include advanced problem solving, software testing, and testing new ortho methods.
- **Government Remote Sensing Analyst, Jeppesen, Englewood, CO, October 2011—December 2011** As a Government Remote Sensing Analyst with Jeppesen, Mr. Orban was responsible for several GIS-oriented tasks surrounding a National Geospatial-Intelligence Agency (NGA) contract with Boeing Defense through Jeppesen. The contract's essential role was using primarily geospatial analysis using ESRI software to extract power/utility infrastructure of various countries from updated satellite imagery.
- **Imaging Technician I, Sanborn, Colorado Springs, CO, April 2010—October 2011.** Processed digital orthophotography and performed quality control, project organization, and scheduling. Responsible for successful job completion.

Craig Laben

Geospatial Data Manager

Mr. Laben has a strong background, with over 20 years of experience in remote sensing, GIS, image processing, geospatial analysis and geospatial product quality assurance. He has extensive knowledge of commercial and government satellite and aerial EO, MS, IR and radar imaging systems data and their applications. Mr. Laben has developed algorithms, techniques, processes and metrics to improve the image quality, accuracy and intelligence value of geospatial products. He also has experience in the processing and analysis of geospatial and natural hazards data for damage assessments, risk and vulnerability assessments and mitigation strategies. Mr. Laben has strong project management and technical leadership experience, and has excellent analytical and problem solving skills.

Education

- **MS, Imaging Science** — Rochester Institute of Technology, Rochester, NY, 1993
- **BS, Computer Science** — Rochester Institute of Technology, Rochester, NY, 1986
- **AAS, Computer Science** — Rochester Institute of Technology, Rochester, NY, 1986

Computer Skills

- **Programming** — MATLAB, Python scripting
- **Remote Sensing and GIS Tools** — ESRI ArcGIS, ERDAS Imagine, ENVI, SocetGXP, Socet Set, RemoteView, QTModeler, ERMapper, Photoshop

Publications

- C. Chiesa, P. Cower, C. Laben (2004, Jul). ***"Mapping Flood Risk and Vulnerability in the Lower Mekong Delta,"*** ESRI Map Book Gallery Vol. 20
- C. Laben, (2004, Mar). ***"An Asia Pacific Natural Hazards and Vulnerabilities Atlas Supporting Disaster Management Applications."*** Pacific Disaster Center White Paper
- C. Chiesa, C. Laben, R. Cicone (2003, Nov). ***"An Asia Pacific Natural Hazards and Vulnerabilities Atlas."*** Proceedings, International Symposium for Remote Sensing of the Environment (ISRSE), Honolulu
- C. Laben (2002, Sept) ***"Integration of Remote Sensing Data and Geographic Information System Technology for Emergency Managers and their Applications."*** Optical Engineering, Journal for the International Society for Optical Engineering, Vol. 41, No. 9

Patents

- C. Laben, B.Brower (2000, Jan). ***"A Process for Enhancing the Spatial Resolution of Multispectral Imagery using Pan-Sharpening."*** US Patent #6,011,875
- R. Fiete, C. Laben (1999, Mar). ***"An Adaptive Process for Removing Streaks in Digital Images."*** US Patent #5,881,182

Project Experience

- **US Cities Oblique Program, Multiple Cities Across the USA, October 2013–Present.** Mr. Laben currently manages the Quality Control (QC) and delivery of all acquired aerial AGPS-IMU and imagery data for Sanborn's US Cities Oblique Program. He is responsible for ensuring that staffing requirements are maintained and that all project deliveries are made on-time and within budget, while making sure that all customer quality standards are being met. He interacts daily with the Flight Acquisition Team and gives daily status updates and reports to upper management. He is also responsible for identifying areas in the AGPS-IMU and Image Quality (IQ) processing work-flows for improvement and making sure that process enhancements are developed, implemented and documented.
- **Lockheed Martin Corp., Goodyear, AZ, June 2010–August 2011.** Mr. Laben was the technical lead on a government contract and was responsible for developing image quality metrics that are currently being used to assess the quality and accuracy of national geospatial products. These image quality metrics include: visual ratings, local and global statistical analysis, geo-location and mensuration analysis, histogram analysis and metadata verification techniques.
- **Pacific Disaster Center, Maui, HI, October 2002–October 2004.** Mr. Laben was the project lead for the design, implementation and deployment of the Pacific Disaster Center's (PDC) Global Hazards Atlas. The Global Hazards Atlas is an internet mapping application which can be used to display near real-time and historical natural hazards data around the globe. The Global Hazards Atlas may be accessed at: www.pdc.org/atlas.
- **Eastman Kodak Company, Rochester, NY, May 1998–January 2000.** Under a government contract, Mr. Laben developed a Gram-Schmidt transform pan-sharpening technique that improved the spatial resolution of multispectral (MS) imagery using a higher resolution panchromatic image, but maintained the spectral characteristics of the MS imagery. Existing pan-sharpening techniques improved the spatial resolution of the MS imagery, but changed the spectral content of the MS data, thus degrading the quality of the imagery. Mr.

Laben documented, submitted for, and received a patent for this Gram-Schmidt pan-sharpening technique. This algorithm is currently offered in both ESRI's ArcGIS and EXELIS' ENVI remote sensing software packages.

Work History

- **Geospatial Data Manager, Sanborn, Colorado Springs, CO, October 2013–Present.** Mr. Laben currently oversees the day-to-day activities of the Data Ingest and Geo-positioning departments for all aerial projects within Sanborn's mapping operations. Mr. Laben is responsible for coordinating activities between the flight acquisition team and the production team and ensuring that image quality and accuracy standards are being met. Mr. Laben works with the GPS-IMU and Image Quality Control (QC) teams to optimize workflow and to develop more efficient processes and improve data ingest and QC turn-around times and lower associated costs.
- **Signal/Image Processing Engineer, Sr. Staff., Lockheed Martin Corp., Goodyear, AZ, February 2005–August 2012.** Mr. Laben was a member of the Geospatial Product Quality (PQ) group which performed geospatial product quality assurance and accuracy assessments on national remote sensing products/tools for various government and defense agencies. Mr. Laben was technical lead on multiple programs and was responsible for all PQ activities related to these programs to include: developing detailed test plans, assigning tasks, performing manual and automated regression testing, performing geo-location and mensuration accuracy assessments, identifying/logging/tracking issues, performing issue resolution and verification, and performing requirement verification. As a technical lead, Mr. Laben was responsible for ensuring that all projects were staffed appropriately and were completed on time and within budget. In addition, Mr. Laben developed Standard Operating Procedures (SOPs), regression testing checklists and image quality metrics for the testing of baseline and Advanced Geospatial Intelligence (AGI) products.
- **Sr. Imagery Analyst, Lockheed Martin Corp, Kihei, Maui, HI, January 2001–February 2005.** As a subcontractor, Mr. Laben was a member of the Data and Information Resources Division at the Pacific Disaster Center located in Maui, Hawaii. The PDC utilizes remote sensing and GIS data, impact modeling, risk assessment tools, and visualizations to provide emergency managers, decision makers and disaster management professionals with historical and real-time hazards information products. Mr. Laben coordinated with and conducted various remote sensing and GIS projects for local, state and federal emergency response agencies. Mr. Laben processed and analyzed natural hazards and geospatial data for risk and vulnerability assessments and mitigation strategies. He also was responsible for integrating real-time hazards data into PDC geospatial applications. Additionally, Mr. Laben tasked and trained PDC Imagery Analysts and GIS interns.
- **Imagery Analyst, Eastman Kodak Co., Kihei, Maui, HI, February 1999–January 2001.** Mr. Laben joined the PDC in its early years as an Imagery Analyst, where he produced geospatial products for the disaster management community. As an Imagery Analyst, his duties included: base map imagery and GIS data collection, data processing and mosaic generation, metadata documentation and verification, database population, development of change detection techniques and products, damage assessments during and after a hazard/disaster event, geospatial product development, and post-event product generation.
- **Project Engineer, Eastman Kodak Co., Rochester, NY, December 1988–February 1999.** Mr. Laben was a member of the Commercial and Government Systems Division's, Image Chain Analysis (ICA) group. Mr. Laben was an algorithm developer and conducted studies to improve the image quality of government EO, MS, IR and radar satellite data and products for both hardcopy and softcopy display. He developed numerous techniques and algorithms to enhance image quality and improve the intelligence value of imagery products to include: baseline image processing chain improvements, adaptive sharpening and dynamic range adjustment algorithms, data fusion and pan-sharpening algorithms, low light level imagery optimization, atmospheric normalization, and change detection algorithms. Mr. Laben obtained two patents on image processing algorithms that he developed while working in the ICA.
- **Graduate Research Assistant, Rochester Institute of Technology, Rochester, NY, September 1986–December 1988.** While obtaining his Master of Science degree in Imaging Science, Mr. Laben conducted research within the Digital Imaging and Remote Sensing (DIRS) Lab on various remote sensing and image processing projects.

Bryan Blackburn, CP

Sr. Stereo Compiler

Education

- **Civil Engineering**–Nashville State Technical Institute, Nashville, TN, 1989

Certification

- **Certified Photogrammetrist (CP)**—ASPRS, No. 1246

Mr. Blackburn is a Certified Photogrammetrist with over 25 years of experience in photogrammetry and conventional land surveying, including 16 years' experience in management. In addition to his role as Sr. Stereo Compiler for Sanborn, Mr. Blackburn is currently the Tennessee Councilperson for the Mid South Region of ASPRS (American Society of Photogrammetry and Remote Sensing). Mr. Blackburn has extensive experience in photogrammetry and computer technology related to the field of digital mapping, digital terrain modeling (DTM), orthophotography, model preparation, triangulation, and GIS databasing. He has been responsible for project scheduling, triangulation, production and management, initializing new projects, and training new personnel. Mr. Blackburn is proficient with Intergraph ImageStation, ISAT and Microstation.

Project Experience

- **Bowling Green, KY, Airport, March 2009—April 2009.** This project consisted of collect planimetrics features at 1"=100' and 2' contours.
- **Monticello, KY, Airport, April 2009—May 2009.** This project consisted of collect planimetrics features at 1"=100' and 2' contours.
- **Columbus, GA, October 2007—December 2007.** This project consisted of collecting bridges, road centerlines, building footprints and updating the 2-foot contours for the county. The imagery was collected with the ADS40 camera.
- **Tennessee Statewide Base Mapping Program, 2000—2003.** This project consisted of mapping the entire state of Tennessee with 100 and 400 scale map sheets. Mr. Blackburn worked in all aspects of this project from sales, setup, production and Quality control.
- **Additional projects executed over the past 25 years include the following:**
  - **Department of Transportation Interstate 840 project, Nashville, Tennessee.** This project consisted of the production of 100-scale planimetric, 5-foot contour topographic maps for the proposed interstate highway, including three different corridors for consideration by the state in determining the most suitable.
  - **US Army Corps of Engineers Jacksonville District.** This project required the creation of digital orthophotos with planimetric and DTM data for use in environmental studies for an area along the Kissimmee River in Florida.
  - **Tennessee Titans NFL Football Team, Nashville, Tennessee.** Created a 40-scale, 1-foot contour map of the proposed site for the new stadium.
  - **Jefferson County, Alabama.** Participated in the production of digital orthophotos. For this project it was necessary to devise a procedure for collecting the information desired to be depicted on the maps to be used for tax mapping purposes.
  - **Koscuisko County, Indiana.** Participated in the creation of digital orthophotos and produced maps with roads, bridges, water features, and DTM data.
  - **Nashville Gas Company, Nashville, Tennessee.** Participated in the generation of a planimetric map depicting gas meters and addresses related to those buildings having gas service. This product was used to enhance emergency response to 911 calls and was updated annually.
  - **Federal Government.** Participated in the production of digital orthophotos and related mapping for a 19-mile section of the Grand Canyon beginning at the Hoover Dam for use in determining the plant life that

would be adversely impacted by flooding of the canyon. This study was endorsed by Vice President Albert Gore.

- **Tennessee Park and Recreation Agency.** Participated in the production of a 40-scale, 1-foot contour topographic map for use in designing a new golf course to be constructed at Tims Ford Lake near Tullahoma.
- **Federal Aviation Agency.** Participated in creating digital mapping containing elevations of the tops of all buildings, structures, utilities, and vegetation existing in the relative proximity of approximately 20 airports throughout the state of Tennessee. This project was related to determining minimum flight path elevations.
- **Municipality of Oklahoma City, Oklahoma.** Participated in the production of a city-wide 3-D GIS land base for multi-purpose uses including tax mapping, site planning and development, utility locations, 911 assistance, and general mapping.

Work History

- **Sr. Stereo Compiler, Sanborn, Colorado Springs, CO, 2013—Present.** Mr. Blackburn assists the Photogrammetric department in the collection of 3D features and in performing Quality Control review of collected data.
- **Owner/ Operator, Mid South Mapping, Shelbyville, TN, 2013—Present.** Mr. Blackburn's duties for Mid South Mapping are to perform Project Setup, Data Collection and Quality Control. He performs all project management for the company, as well as all sales and marketing.
- **Production Resource Manager, The Atlantic Group, Huntsville, AL, 2009 – 2013.**
- **Owner /Operator, Mid South Mapping, Shelbyville, TN, 2006 – 2009.**
- **Mapping Department Supervisor and Triangulation and Control Manager, G-Squared, LLC, Park City, TN, 2005 – 2006.**
- **Business Development Division and Photogrammetry Team Lead, EarthData International of Maryland, Frederick, MD, 2000 – 2005.**
- **Supervisor, Mapping Services Division, Wiser Company, LLC, Murfreesboro, TN, 1996-2000.**
- **Photogrammetrist, Caddum, Inc., Nashville, TN, 1995-1996.**
- **Photogrammetrist, Atlantic Technologies, Ltd., Huntsville, AL, 1989-1995.**
- **Rodman and Draftsman, Jesse Walker Surveying, Nashville, TN, 1987-1989.**
- **Rodman and Draftsman, Doyle M. Caffey Surveying, Shelbyville, TN, 1985-1987.**

Bree Connell

PMO Coordinator

With 10 years of experience in the GIS and mapping industry, Ms. Connell possesses the skills necessary to coordinate schedules and resources at Sanborn's Colorado Springs facility. She supports both Project Management and Production technically, scheduling on large projects. She oversees project scheduling as well as resource coordination, to ensure the project team delivers quality products and services within budget and on time. She oversees data flow among departments on large-scale products. Her experience encompasses multiple orthoimagery projects and she is accomplished at coordinating project efforts with on-site customer staff as well as off-site subcontractors. She also has experience as a project lead on large scale orthorectification jobs.

Education

- **BA, Geography and Environmental Studies**—University of Colorado, Colorado Springs, CO, 2003

Technical Expertise

- APS (Sanborn's Proprietary Software)
- ArcGIS 8.3, 9.0, 9.1, 9.2, 9.3, 10.0
- Global Mapper
- Primavera 6.0
- Microsoft Office Suite

Project Experience

- **State of Michigan Program 2014, MI, April 2013—Present.** Supports the Project Manager by providing full project coordination for large statewide multi-year project. Coordinates schedule and delivery milestones to adhere to contract requirements. Communicates resource requirements to production managers. Coordinates shipments, deliveries, schedules and issues with multiple subcontractors. Tracks project progress, metrics, and production issues to ensure that all resources have the materials and information needed to complete the entire project on budget and schedule, while adhering to quality assurance and ISO requirements.
- **Maricopa County, AZ, October 2013–March 2014.** Supported the Project Manager by providing full project coordination for large statewide multi-year project. Coordinated schedule and delivery milestones to adhere to contract requirements. Communicated resource requirements to production managers. Coordinated shipments, deliveries, schedules and issues with multiple subcontractors. Tracked project progress, metrics, and production issues to ensure that all resources have the materials and information needed to complete the entire project on budget and schedule, while adhering to quality assurance and ISO requirements.
- **State of Michigan Program 2013, MI, April 2013—Nov 2013.** Supported the Project Manager by providing full project coordination for large statewide multi-year project. Coordinated schedule and delivery milestones to adhere to contract requirements. Communicated resource requirements to production managers. Coordinated shipments, deliveries, schedules and issues with multiple subcontractors. Tracked project progress, metrics, and production issues to ensure that all resources have the materials and information needed to complete the entire project on budget and schedule, while adhering to quality assurance and ISO requirements.
- **New York State Digital Orthoimagery Program, NY, March 2013—Feb 2014.** Supported the Project Manager by providing full project coordination for large statewide multi-year project. Coordinated schedule and delivery milestones to adhere to contract requirements. Communicated resource requirements to production managers. Coordinated shipments, deliveries, schedules and issues with multiple subcontractors. Tracked project progress, metrics, and production issues to ensure that all resources have the materials and information needed to complete the entire project on budget and schedule, while adhering to quality assurance and ISO requirements.
- **New York State Digital Orthoimagery Program, NY, June 2012—Jan 2013.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **Louisville-Jefferson Information Consortium (LOJIC), KY, May 2012—January 2012.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.

- **Maricopa County, AZ, November 2011–February 2013.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **United States Department of Agriculture (USDA), National Agriculture Imagery Program (NAIP), VA, May 2011—October 2011.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **United States Department of Agriculture (USDA), National Agriculture Imagery Program (NAIP), VA, June 2010—December 2010.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **Maricopa County, AZ, March 2011—June 2011.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **United States Department of Agriculture (USDA), National Agriculture Imagery Program (NAIP), June—September 2009.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.
- **New York State Digital Orthoimagery Program, NY, June 2008—December 2008.** Lead ortho production from setup to verification of final deliverables. Verified data inputs and outputs and updated project status and tracking documents.

Work History

- **PMO Coordinator, Colorado Springs, CO, March 2013—Present.** Ms. Connell coordinates production of large multi-year statewide projects across Sanborn's Mapping division. Ms. Connell supports Project Management, Production, Project Client, and Subcontractors with project scheduling design and statusing. Ms. Connell coordinates projects from inception through full production to completion, to include aerial imagery acquisition, surface compilation and ortho production. Ms. Connell has project involvement in the pilot, production, and final delivery phases by providing support to Project Management and Operations in scheduling, coordination and technical support. She develops project-specific documentation, and works with clients and local management to establish and maintain schedules and ensure the overall success of the project. Ms. Connell coordinates weekly resource and metric meetings, monthly project schedule review meetings and quarterly project budget review meetings with the CEO, General Managers, Accounting, Project Manager and Production. Ms. Connell provides technical support to Project Managers by attending weekly conference calls. Ms. Connell works to document and improve production process flows.
- **Imagery Analyst Team Lead, Sanborn, Colorado Springs, CO, 2012—March 2013.** Ms. Connell designed production work flows to maximize efficiencies with existing and developing technologies. She managed technicians, including daily operations. Performed internal ISO audits and updated ISO documentation as necessary. Managed mapping projects, including technical setup/execution and metric tracking to ensure strict adherence to budgeted hours/schedules.
- **Senior Production Team Lead, Sanborn, Colorado Springs, CO, 2011—2012.** Managed multiple concurrent state, federal and private orthorectification projects. Coordinated technical responsibilities involving project setup, troubleshooting problems, translation of data and verifying client deliveries. Created work instruction and training documents in compliance with internal ISO documentation. Maintained project status and tracking documentation.
- **Project Coordinator, Sanborn, Colorado Springs, CO, 2007–April of 2011.** Managed orthorectification jobs: Rectified, color balanced, seamed and mosaiced orthophotos using proprietary software. Provided support and training to technicians to ensure integrity and accuracy of project deliverables.
- **Senior Digital Imaging Technician, Sanborn, Colorado Springs, CO, 2006—2007.** Assisted Project Coordinators with orthophoto production tasks. Performed and organized data backups/restores to assist IT with data management. Provided support and training to technicians.
- **Digital Imaging Technician, Sanborn, Colorado Springs, CO, 2004—2006.** Applied photo interpretation skills to perform detailed quality control tasks while maintaining aggressive schedules and adhering to budgeted hours.

Daniel E. Hood

Chief Pilot

Mr. Hood has 40 years of experience in aviation management and as a pilot, both in Alaska and the contiguous US. He has served as Chief Pilot for an FAA Part 121 airline and as Director of Flight Operations for an overseas airline. Prior to joining Sanborn, Mr. Hood gained extensive experience flying digital imagery and LiDAR acquisition missions. Mr. Hood brings over 30,000 hours of total pilot time, and a verifiable perfect safety record. He began his flying experience and career at Merrill Field in Anchorage as a Civil Air Patrol Cadet, and is a certified Airline Transport Pilot qualified by a combination of substantial flight time with years of international experience enhanced by specialized professional training. He is competent and knowledgeable in flight operations management, with specific expertise in medium and large aircraft with digital and integrated avionics.

Education

- **Flight Engineering**—Boeing Aircraft Company, Seattle, WA

Licenses and Certifications

- **FAA ATP Certificate**—Airline Transport Pilot, No. 1499590
  - Airplane Single- and Multi-Engine; Land and Sea
  - A-310, B707, B720, B727, B767, CV240, CV340, CV440, DC-8, IA-Jet
- **FAA Certificate**—Flight Engineer, No. 1677110
- **FAA Certificate**—Flight Navigator, No. 1787144
- **Flight Instructor**—Airplane and Instrument

Flight Hours

- **Total Pilot Time: 30,151 Hours**
  - Pilot in Command: 25,900
  - Boeing Aircraft: 19,950
  - General Aviation (Jet and Piston): 7,100
  - Flight Engineer: 4,389
  - Flight Instructor: 2,150
  - Flight Navigator: 1,150

Project Experience

- **Virginia Base Mapping Program, VA, November 2011—Present.** Oversees imagery acquisition by coordinating the pilots and aircraft according to the project schedule, and monitoring the collection window and the quality of acquisition.
- **New York State Digital Orthophotography Program, NY, November 2011—Present.** Oversees imagery acquisition by coordinating the pilots and aircraft according to the project schedule, and monitoring the collection window and the quality of acquisition.
- **Maricopa County, AZ, November 2011—Present.** Aerial Imagery Project. Oversees imagery acquisition by coordinating the pilots and aircraft according to the project schedule, and monitoring the collection window and the quality of acquisition.
- **Saskatchewan Province, Canada, April 2012—Present.** Orthoimagery Program. Oversees imagery acquisition by coordinating the pilots and aircraft according to the project schedule, and monitoring the collection window and the quality of acquisition.
- **Gwinnett County, GA, November 2011—Present.** Orthoimagery, LiDAR, and Planimetric Mapping. Oversees imagery acquisition by coordinating the pilots and aircraft according to the project schedule, and monitoring the collection window and the quality of acquisition.

Work History

- **Chief Pilot, Sanborn, Colorado Springs, CO, November 2011—Present.** As Chief Pilot, Mr. Hood has overall responsibility for pilot training, aircraft maintenance and the safety of Sanborn's flight operations. He develops standard operating procedures, creates and implements training programs, hires and manages pilots, and supervises sensor operators.
- **Pilot, Marc, Inc., Bolton, MS, 2008—2011.** Part-time pilot. Experience flying twin-engine aircraft to support digital imagery and LiDAR acquisition.

- **Captain, Delta Air Lines, Atlanta, GA, 1991—2004.** Captain – Boeing 767ER/757/A-130/727. Line Captain, Instructor, First Officer, Flight Engineer and Navigator. Primarily engaged in international and domestic flight operations with years of experience in Boeing aircraft worldwide. Extensive general aviation experience in single- and multi-engine land and sea in Alaska and lower 48 states.
- **Captain, Pan American Airlines, New York, NY, 1967—1991.** Captain – Boeing 767ER/757/A-130/727. Line Captain, Instructor, First Officer, Flight Engineer and Navigator. Primarily engaged in international and domestic flight operations with years of experience in Boeing aircraft.

Deborah Barnes

Team Lead, GIS

Ms. Barnes has more than 15 years of experience in mapping and data development, and has served as the Team Lead in the GIS and Photogrammetry departments. As the GIS Team Lead, she is responsible for training and implementing tools to increase Sanborn's efficiency in meeting the USGS version 13 specifications for hydro production. Ms. Barnes has extensive experience in database management systems and spatial technologies on multiple hardware and software environments and the implementation of new technologies to improve end user productivity.

Education

- **Certificate, Noncommissioned Officer**—United States Air Force Noncommissioned Officer Academy, 1994

Affiliations and Certifications

- **American Council of Engineering Companies**—Supervisor Skills I, Certificate, 2003

Project Experience

- **Gwinnett County, GA, June 2013—Present.** Responsible for GIS QC and delivery of updated Planimetric and Topographic data for 1:100' scale mapping for Gwinnett County. Our performance has led to award of additional years of updating projects.
- **Greater Bridgeport Regional Council, Bridgeport, CT, June 2013—Present.** Responsible for GIS QC and delivery of Planimetric data for 1:50 scale mapping, including annotation contours. Also, responsible for creating, editing and QC'ing Topographic data.
- **City of Stamford, CT, May 2012—Feb 2013.** Responsible for GIS QC and delivery of updated Planimetric and Topographic data for 1:50' scale mapping, including annotation for contours.
- **Township of Livingston, NJ, May 2012—January 2013.** Responsible for GIS QC and delivery of updated Planimetric and Topographic data for 1:100' scale mapping.
- **State of Kansas LiDAR, KS, March 2012—Present.** Responsible for delivery of hydro-flattened rivers and waterbodies, and tiled hydro-flattened DEM for three counties. Project accepted with few issues. Our performance led to selection for an additional 6 Kansas Counties for 2013.
- **Louisville and Jefferson County Metropolitan Sewer District, KY, January 2013—Present.** Responsible for delivery of 922 square miles of hydro flattened rivers and waterbodies, and hydro flattened DEM sufficient for 2-foot contours. This project was completed on time under a compressed schedule.
- **Lewis and Clark County, MT, June 2012—September 2012.** Responsible for collection of hydro breaklines, hydro flattening of rivers and waterbodies and creating a hydro flattened DEM and contours. First time acceptance of data.
- **South Carolina Department of Natural Resources 2010, SC, April 2011—February 2012.** Responsible for delivery of GIS products including hydro flattened DEM for seven SC counties. Increased production efficiency by 80%. Used python scripting to decrease the manual labor in pre-production of data. Trained other employees on hydro flattening tasks by implementing the use of tools developed internally.
- **American Samoa Villages, National Oceanic and Atmospheric Administration (NOAA), American Samoa, October 2011—November 2011.** Responsible for creation of all GIS products from a combination of mobile LiDAR and other surveyed points to accurately map the ground up to 30 feet for tidal wave evacuation planning in seven villages hard hit by the 2009 tidal wave.

Work History

- **GIS Team Lead, Sanborn, Colorado Springs, CO, February 2011—Present.** Leads the creation of all products, training and tool implementation for the GIS department. Supervises, monitored, and trained processing technicians; scheduled and coordinated projects; oversaw production standards; coordinated project startups; provided technical support; assisted GIS users; and, performed quality audits.

- **Senior GIS Analyst, Merrick & Company, Aurora, CO, May 1995—August 2009.** Executed multiple projects as Team Project Lead, accomplished 95% accuracy and client satisfaction from data collected, coordinated and facilitated projects while learning new software and training others at the same time, managed quality control efforts, developed and documented procedures. Directed Team performance on data compilation tasks, compiled data from ortho-photos and satellite imagery, edited LiDAR, edited planimetric data and parcel mapping. Instrumental part of two teams that won annual quality awards.
- **Imagery Intelligence Analyst, United States Air Force and Reserves, June 1986—April 1994.** Analyzed information and wrote reports on sensitive intelligence data from Imagery using both 2D and 3D compilation methods. Awarded Airman of the Quarter for outstanding dedication, initiative and professionalism; and, earned an Eagle Eye Award for superlative intelligence analysis.

Karol Szczubełek

AGPS and Operations Team Lead

Mr. Szczubełek has over 13 years of experience in geodetic surveying. As team lead, Mr. Szczubełek provides leadership and technical expertise in ortho photo production and directs and coordinates the daily work of the orthoimagery team in processing of aerial imagery. Mr. Szczubełek has been actively involved in the geodetic surveying, aerial photography, and LiDAR data collection. Office duties have involved GPS/IMU, digital, and analog camera and LiDAR data processing at Sanborn. He is responsible for implementing and establishing methods for maximizing accuracies of processing geodetic survey data with impressive results. He heads and supervises all surveying activities and survey applications development. Mr. Szczubełek is also responsible for documentation, training, and monitoring all QA/QC activities pertaining to geodetic surveying. He was in charge of coordination, execution, and reporting for a multi-year GPS survey project on several military bases throughout the country for the U.S. government.

Education

- **BS, Geomatics Engineering**—University of Calgary, Calgary, AB, 2001
- **Degree, Electrical Engineering**—Zespol Szkol Elektrycznych, Soltyka, Warsaw, Poland, 1990

Professional Education and Seminars

- Vexcel UltraCam, manufacturer's training
- DMC Camera, manufacturer's training
- Optech ALTM operations, manufacturer's training
- Leica Geosystems ALS50, manufacturer's training
- Yearly sensor operation and field procedures and processing

Project Experience

- **Gwinnett County Basemap Update, Gwinnett County, GA, 2010—Present.** Mr. Szczubelek was responsible for designing/planning the LiDAR acquisition throughout the County. His current responsibilities also include Airborne GPS processing and quality review of the ground control network.
- **Oblique Imagery Program, Customer Confidential, Multiple Cities, June 2013—Present.** Process and adjust Ground Control points for AT process. Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Bourbon and Crawford Counties, KS, May 2014.** Process and adjust ground control points for AT process. Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Tennessee Department of Transportation (TDOT) Portland Bypass, TN, April 2014.** Process and adjust ground control points for AT process. Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Pikes Peak Geospatial Alliance (PPGA), Colorado Springs Utilities, Colorado Springs, CO, May 2014--Present.** Process and adjust ground control points for AT process. Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Louisiana Statewide, LA, February 2010—June 2012.** Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Maricopa County, AZ, October 2009—Present.** Processing AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Virginia Base Mapping Program, VA, February 2007—July 2012.** Conducted the establishment of the Statewide GPS control network. Processing AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **Saskatchewan Province Orthoimagery Program, Saskatchewan, Canada, April 2012–Present.** Oversees and coordinates field operations, including flight planning, sensor operators, and network adjustments.

- **Qatar Petroleum Aerial Photogrammetry Based GIS Database Updating Program, Qatar, January 2013–Present.** Oversees and coordinates field operations, including flight planning, sensor operators, and network adjustments.
- **State of Kansas, March 2011–Present.** Oversees and coordinates field operations, including flight planning, sensor operators, and network adjustments.
- **National Agriculture Imagery Program, U.S. Department of Agriculture, VA, 2008.** Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **City of Rifle, CO, April 2009.** Performed Real Time Kinematic (RTK) observations of the following utilities: storm, sanitary, water and traffic signs.
- **US Department of Agriculture Forestry, US Department of Agriculture Farm Service Agency, CO, WY, July 2008–September 2008.** Processed AGPS-IMU airborne trajectory to establish aerial imagery photo centers.
- **EarthTech ACC, US Air Force Bases, February 2004–September 2005.** Established a first order control network for utility data collection for 14 Air Force bases throughout the United States. This included data collection of the following utilities: storm, sanitary, water, electrical, natural gas, and liquid fuels. Performed RTK survey involving Trimble 5,700 receivers.
- **Denver Water Utilities, CO, April 2002.** Established a first order control network for utility data collection and data collection of the water utilities. Performed RTK survey using Trimble 5,700 receivers.
- **Naperville, IL, May 2001.** Utility Project. Established a first order control network for utility data collection and data collection of the following utilities: storm, sanitary, and water. Performed RTK survey involving Trimble 4,000 SSI receivers.

Work History

- **AGPS and Operations Team Lead, Sanborn, Colorado Springs, CO–December 2013 - Present.** In addition to the below responsibilities, Mr. Szczubelek is responsible for the airborne GPS and ground survey operations.
- **Data Logistics Manager, Sanborn, Colorado Springs, CO, June 2012–December 2013.** In addition to the below responsibilities, Mr. Szczubełek is responsible for all aircraft sensors, related equipment, flight planning, and sensor operators.
- **Geodetic Engineer, Sanborn, Colorado Springs, CO, May 2001–June 2012.** Responsibilities include managing/planning, sensor operation, troubleshooting, photography and LiDAR data collection and processing, and quality control. Mr. Szczubełek is also responsible for survey and ground control for all mapping and GPS survey projects.

Shaukat Hussain, CP

Senior AT Analyst

With over 29 years' experience, Mr. Hussain's career background includes working as a Photogrammetrist for Survey of Pakistan, Saudi Aramco, Geonex International, MAPS UAE, Bahrain Center for Studies and Research, Stewart Geo Technologies, and United Geo Technologies, and is currently with The Sanborn Map Company, Inc. His experience includes shift and production management of photogrammetric operations.

Mr. Hussain's technical background includes extensive project experience performing conventional and softcopy analytical aerotriangulation using seven different programs, and integration of airborne GPS data. He has performed extraction of terrain and planimetric data on analog, analytical and softcopy stereoplotters, including state-of-the-art LH Systems, Intergraph and Leica LPS digital photogrammetric workstations. He has also performed extensive image scanning, digital orthophotography, image processing production, flight mission planning, control layout for photogrammetric blocks, project planning, assistance in proposal preparation, and time and cost estimation management. His skills include programming, the ability to operate virtually any mainstream CADD and photogrammetric mapping software, and experience with the Esri GIS software suite.

Education

- **BS, Mathematics**—Punjab University, Pakistan, 1982
- **MA, Economics—**Punjab University, Pakistan, 1985
- **Post Graduate Diploma, Photogrammetry—**International Institute for Aerospace Survey and Earth Sciences, The Netherlands, 1990
- **Advanced Windows Application Programming Using Visual Basic 6—** University of California, Irvine, CA, 2002
- **Introduction to Python Programming—** NISD San Antonio, TX, 2012

Affiliations and Certifications

- **Certified Photogrammetrist (CP)**—ASPRS, No. 1256, 2005

Project Experience

- As the Senior AT Analyst for Sanborn, Mr. Hussain provides aerotriangulation management and serves as Certified Photogrammetrist for many projects. The following is a list of selected projects:
  - **Oblique Imagery Program, Customer Confidential, Multiple Cities, July 2013—Present.**
  - **Maricopa County, AZ, August 2013—Present.** Maricopa County is a 3-inch Orthoimagery program.
  - **State of Michigan, MI, July 2013**
  - **Metro-2-Metro Aerial Photography Update, MS, June 2013—July2013.**
  - **Virginia Base Mapping Program (VBMP), VA, June 2013—July 2013.**
  - **Manistee County, MI, May 2013—June 2013.**
  - **US Cities, Customer Confidential, Multiple Cities, August 2013—Present.**
  - **Greater Bridgeport Regional Council, CT, May 2013.**
  - **Iredell County, NC, April 2013–Present.** Oblique imagery program. Role: AT manager and certified photogrammetrist.
  - **Southern Nevada Water Authority, NV, April 2013–May 2013.** SNWA is a multiyear orthophotography contract that requires the acquisition of natural color and color infrared digital imagery and the production of 6-inch digital photography. Role: AT manager and certified photogrammetrist.
- **City of Ardmore, OK, United Geo Technologies, March 2012–August 2012.** GIS/Topography update project. The scope of the project was to update topographic and raster layers, and related attributes in existing geo database created in 2007. Roles included flight and control planning, production and outsource management, and quality assurance.

- **Webb County, TX, Stewart Global Solutions, 2009–2011.** GIS Parcels update project. This was an ongoing yearly update of parcels database for Webb County. Roles included outsource management and quality assurance.
- **Floodplain Study GIS Projects, Flood Control District of Maricopa County, AZ, 2003–2011.** Several projects from 2003 through 2011. Scope included preparation of feature classes for client-designed geo database with very strict rules and specifications. Roles included flight and control layout, aerial triangulation, production and outsource management, CAD to GIS translation, and quality assurance. Saved considerable man hours by utilizing scripting and programming.
- **Maricopa County DTM and Ortho Photography, AZ, 2001–2005.** In 2001, collected terrain data and produced/updated orthos yearly for five years. Roles included aerial triangulation, terrain collection supervision, orthophoto production, quality assurance, and mentoring. Saved significant amount of man hours through automation, scripting and programming.
- **Bahrain Island and Territorial Waters GIS Master Plan, Bahrain Center for Studies and Research, Manama, Bahrain, 1998–2000.** GIS master plan for entire country of Bahrain and territorial waters. Color, BW and infrared raster layers, topographic layers including structures, utilities, drainage, pipelines, vegetation, etc. Roles included aerial triangulation, topographic and terrain data collection, orthophoto production, image tone matching, quality assurance and mentoring.
- **Medinah City GIS, Geonex International, Riyadh, Saudi Arabia, 1995–1996.** Project scope was to produce 1:10000 and 1:1000 maps with feature attributes for GIS. Roles included shift and production supervision, aerial triangulation, stereo compilation, quality assurance, and mentoring. The big achievement in this project was to form and train a team of raw graduates who became professional technicians in a very short period of time.
- **Kalabagh Dam Mapping, Survey of Pakistan, NWFP Province, Pakistan, 1984–1985.** Performed feature and terrain collection on stereo analog instruments for 1:1000 map scale with 1-meter contours.

Work History

- **Senior AT Analyst, Sanborn, Colorado Springs, CO, April 2013–Present.** Leadership role in aerial triangulation, control layout and flight planning, workflow streamlining and automation, and other tasks as needed.
- **Production Manager, United Geo Technologies, San Antonio, TX, January 2012–April 2013.** Supervise digital Mapping & Ortho projects to meet specifications, timely completion, quality assurance and quality control. Secondary tasks include computer programming, flight planning, time and cost estimation for business development.
- **Production Manager, Stewart Global Solutions, San Antonio, TX, April 2000–December 2011.** Supervise digital Mapping & Ortho projects to meet specifications, timely completion, quality assurance and quality control. Secondary tasks include computer programming, flight planning, time and cost estimation for business development.
- **Photogrammetrist, Bahrain Center for Studies and Research, Manama, Bahrain, June 1998–March 2000.** Perform aerial triangulation, manual DTM compilation, Ortho rectifications and Mosaicking, image tone matching and image balancing for entire island of Bahrain at three different scales on color, black & white and infrared photography.
- **Photogrammetrist, MAPS Geosystems, Sharjah, United Arab Emirates, August 1996–December 1997.** Aerial Triangulation, Measurements, Analysis and Adjustment. Ortho rectifications and Mosaicking, Image tone matching and image balancing, CAD editing, R & D
- **Photogrammetrist, Geonex International, Lahore, Pakistan, and Riyadh, Saudi Arabia, January 1994–July 1996.** Aerial Triangulation, DTM Auto correlation and editing, Ortho rectifications, High resolution image printing of raster with overlaying vector graphics. Photogrammetric scanning, CAD editing, Archiving, Supervision, Training to fellows, Project & shift management, QA/QC

- **Aerial Triangulation Analyst, Saudi Aramco, Dhahran, Saudi Arabia, August 1992–December 1993.** Aerial Triangulation Analysis and Adjustment, CAD editing, Shift Scheduling, R&D, Project Planning
- **Survey Officer, Survey of Pakistan, Rawalpindi, Pakistan, July 1983–August 1993.** Supervision, Project Planning, Aerial Triangulation, Production Management, Stereo Compilation, QA/QC, Land Surveying, Training to fellows.

Steven A. Wood, LS, CP

Registered Land Surveyor

Mr. Wood combines an extensive land surveying and civil engineering background with more than 42 years of project management experience in engineering, land development, surveying and photogrammetry. He has developed several customized solutions for industry-leading photogrammetric projects. His surveying experience is comprehensive and includes many years of practical field assignments and office management of more than a dozen survey field crews. Projects include almost every type of surveying including land boundary, construction staking, flood insurance cross section surveys, ALTA minimum standard surveys, power plant layout, right of way takings, GPS control surveys for control densification and photo control projects, precise second order control surveys, differential and on the fly GPS field inventory of utilities, and Department of Defense GIS mapping and field inventory. Mr. Wood has also served as the Surveyor in Responsible Charge overseeing multi-participant municipal mapping and surveying projects for many countywide landbase mapping projects throughout the US and overseas. Mr. Wood has helped implement innovative surveying uses of current technology to accomplish timely and economical survey solutions throughout his career.

Education

- **BS, Land Surveying**—Purdue University, West Lafayette, IN, 1974
- **AAS, Civil Engineering Technology—** Purdue University, West Lafayette, IN, 1972

Affiliations and Certifications

- **Certified Photogrammetrist (CP)**—ASPRS, No. R899, 1993
- **Registered Land Surveyor—**Licensed in the following 17 states: Arkansas, California, Colorado, Florida, Illinois, Indiana, Kansas, Louisiana, Maryland, Montana, New Mexico, North Carolina, Ohio, Oklahoma, Wyoming, North Dakota, South Dakota

Project Experience and Work History

- **Land Surveyor, Sanborn, Colorado Springs, CO, 2005—Present.** Mr. Wood has performed land survey services for Sanborn for many projects, including Manistee County, Michigan: Lewis and Clark County, Montana; Ellsworth AFB, South Dakota; Clay County, Kansas; and Haskell County, Kansas.
- **Principal in Responsible Charge, privately operated small business, March 2000—Present.** Mr. Wood is responsible for all aspects of geodetic survey control for photogrammetric mapping control of several large projects and county-wide mapping programs, including several public agencies.
  - Several surveying and mapping control projects throughout Oklahoma including work on Oklahoma City and surrounding area mapping control, several lakes throughout Oklahoma for the Corps of Engineering (COE), Fort Sill, McAlester, and various air force bases.
  - Several control projects in Kansas including work in Hays County, Ellis County, Anderson County, Haskel County, Garden City, Finney County and Fort Riley. Mr. Wood also ran several COE lake mapping projects throughout Kansas.
  - Perform surveying and GIS consulting reviews of project deliverables including final aerotriagulation solution for Dekalb County, Indiana work performed by large mapping industry firm.
  - Gps photo control projects for following counties/projects including Wayne County, Indiana; Brown County, Indiana; Brazil, Indiana; Bradford Woods, Indiana; Champaign County, Illinois; Lee County, Illinois; Whiteside County, Illinois; Branson, Missouri; Nauvoo, Illinois; South Lyon, Michigan; Eastern Illinois University, Illinois; Greencastle, Indiana; Alcoa Lafayette, Indiana; Peoria County, Illinois and numerous smaller local sites. Scope includes contracting NGS control recovery and densification, and producing field work and office reports.
  - Gps geodetic survey photo control for DOD Air Force Military Installations in Kansas, Texas, Tennessee, Mississippi, Alabama, Florida, Oklahoma, Ohio, Arkansas, California, Maryland, New York, Pennsylvania, New Hampshire, and Colorado.

  - Gps photo control projects in Kansas, Illinois, Maryland, New Jersey, Kentucky, Iowa, California and Missouri.
  - Gps route survey control for MODOT highway project in Missouri.
  - McAlester Army Depot, Oklahoma gps surveys.
  - Dam reclamation rehabilitation surveys in Oklahoma for USDA.
  - Gps surveys in Maryland; New Jersey; Missouri; Naperville, Illinois; Canton, Illinois; Butler County, Ohio; and Lucas County, Ohio.
  - Gps photo control surveys for Lamar County, Mississippi; Pike County, Mississippi; Jackson Energy, Jackson, Tennessee; City of Cleburne, Texas; Euless, Texas; Norman, Oklahoma; Lubbock, Texas; COE surveys in Bowie County, Texas and Fort Sill, Oklahoma; Gps surveys for Stark County, Illinois; McHenry County, Illinois; Jasper County, Indiana; Wayne Co, Indiana; Dekalb Co, Indiana; and Mesa County, Colorado.
  - Extensive LIDAR quality control field checking for imagery along Mississippi River from Cairo to Minneapolis also Illinois River from St Louis to Dekalb.
  - Gps control for high speed rail route from St. Louis to Chicago.
  - Gps control for MD DOT mass transit lines.
  - Gps control for 13 county multi-participant mapping project around Houston.
  - Gps control for 4 county multi-participant mapping project east of Dallas.
  - Gps control for two county mapping project in southwest Kansas.
  - Gps control for mapping projects for dozens of military sites all across the US.
  - Extensive LIDAR ground truthing QC surveys in Illinois, Arkansas, California, and Missouri.
  - USDA NRCS WRP easement surveys in Indiana, Ohio, and Pennsylvania.
- **Vice President Photogrammetry, MSE Corporation/ASI, Indianapolis, IN, February 1993—March 2000.** Managed production operations of state of the art photogrammetry mapping division, includes survey ground control, ABGPS, aerotriangulation, mapping, softcopy and digital orthophoto production operations. MSE was acquired by ASI in July 1997. Role expanded in 1998 to include management of corporate mapping subcontractors, coordinating work across all ASI mapping locations and reviewing and facilitating implementation of new mapping technology. Travel to New Zealand and Portugal to review mapping vendor capabilities and assist in Sales efforts.
- **Vice President Operations, MSE Corporation, Indianapolis, IN, May 1983—February 1993.** Supervised, managed and administered production operations of over 150 employees involved in civil engineering, transportation, aviation, surveying, photogrammetry and digital computer graphics (GIS) branches of company.
- **Director, Surveying and Mapping Operations, MSE Corporation, Indianapolis, IN, May 1981—May 1983.** Combined management responsibility for all surveying and photogrammetric mapping performed by company.
- **Director, Survey Operations, MSE Corporation, Indianapolis, IN, May 1979—May 1981**. Direct responsible charge all survey operations for 12 crews all types surveying and civil engineering projects.
- **Survey Project Manager, MSE Corporation, Indianapolis, IN, March 1975—May 1979**. Supervised special survey projects, managed field office and supervised field crews.

Section 4 – Exceptions to the RFP

Sanborn understands that many of the basic terms and conditions in the RFP are based upon statutory or regulatory requirements and are not subject to negotiation. Sanborn notes that certain terms and conditions may or may not be applicable to this procurement, or may require adjustment based on the specifics of this procurement; and, reserves the right to discuss and negotiate these terms and conditions during the contract negotiation. Sanborn is confident that a mutually acceptable Contract will be negotiated upon selection that is based upon and reflects the final project specifications, deliverables, schedule, and fees.

Section 5 – Additional Pertinent Information

Sanborn has thoroughly reviewed your RFP and associated documents and found them to be clear and concise, and is not aware of any omissions from the RFP. Sanborn has successfully completed dozens of projects that are similar in size, scope, and required deliverables to your program. We can meet or exceed all specifications, and have responded to all requirements.

All descriptions of alternative or optional functionality that Sanborn has deemed to be potentially advantageous or beneficial to COAGA 2015 have been presented in Section 2, Project Approach, of this proposal response.

One unique differentiator that we offer COAGA 2015 is the option for each participant to decide if they want delivery of the 4th band (NIR) as part of the orthoimagery layer, at no additional cost. This band is very valuable for a myriad of applications, such as land cover classification, storm water mapping, etc.

Section 6 – Fee Proposal

Sanborn has prepared the following pricing based upon our understanding of the RFP and the technical description, specifications, deliverables, acceptance criteria and schedule (scope of work) provided in our proposal. Sanborn's price includes utilizing existing client-supplied terrain surface data to generate orthoimagery utilizing new imagery data to be collected in Spring of 2015 to update the surface as needed. An alternative price structure utilizing off-shore production resources has been provided as a cost saving option for COAGA 2015.

In addition, Sanborn has provided optional pricing below for the city of Edmond per the Q&A which asked for pricing to add driveways and then a price to add the remaining impervious features in addition to driveways.

On the following page, Sanborn is providing pricing that would provide a greater value to COAGA 2015 if larger contiguous areas were selected at the same GSD for imagery. Also, Sanborn is showing a price to provide LiDAR for all of Oklahoma County at the same specifications. Moore and Norman can be added to this pricing at the same $/mile if they desire the same product.

Sanborn has provided pricing for these larger areas to demonstrate the potential savings if larger areas are chosen with uniform products. If different combinations of contiguous AOIs (other than shown in the RFP) are chosen, in which the same products are desired, Sanborn is happy to provide custom quotes upon request to discuss discounts based on economies of scale. Otherwise, the pricing provided in the Cost Proposal Form can be utilized.

As always, Sanborn is willing to negotiate the final project scope of work and related fees.

Executed Non-Collusion Affidavits for each of the COAGA 2015 entities named in the RFP are provided on the pages following the price form.

Please note that Sanborn considers our pricing information to be confidential and proprietary, as it is reflective and manifest of confidential and proprietary technologies, methods and procedures.

SPA

Additional Optional Pricing: Onshore			
Area	**Product**	**Sq Miles**	**Price**
City of Edmond	add driveways	110	$ 17,045.84
	add remaining impervious	110	$ 36,390.95
COAGA 2015 AOI	6-inch	~1010	$ 62,640.01
	3-inch	~1010	$ 227,600.05
Oklahoma County	1.4m LiDAR	~718	$ 61,264.81
	Breaklines	~718	$ 9,740.53
	HE-DEM	~718	$ 10,932.52
	2-foot Contours	~718	$ 21,790.94
	0.7m LiDAR	~718	$ 91,938.17
	Breaklines	~718	$ 9,740.53
	HE-DEM	~718	$ 10,932.52
	1-foot Contours	~718	$ 43,220.12

Additional Optional Pricing: Offshore			
Area	**Product**	**Sq Miles**	**Price**
City of Edmond	add driveways	110	$ 8,282.47
	add remaining impervious	110	$ 17,612.30
COAGA 2015 AOI	6-inch	~1010	$ 43,189.87
	3-inch	~1010	$ 140,851.95
Oklahoma County	1.4m LiDAR	~718	$ 44,823.88
	Breaklines	~718	$ 5,150.33
	HE-DEM	~718	$ 5,780.60
	2-foot Contours	~718	$ 11,692.50
	0.7m LiDAR	~718	$ 68,410.63
	Breaklines	~718	$ 5,150.33
	HE-DEM	~718	$ 5,780.60
	1-foot Contours	~718	$ 23,023.23

Please note that Sanborn considers our pricing information to be confidential and proprietary, as it is reflective and manifest of confidential and proprietary technologies, methods and procedures.

10 **Cost Proposal Forms:** The COAGA 2015 is seeking firm fixed prices for the performance and delivery of digital orthoimagery and flight plan map. Prices shall cover all necessary work, materials, supplies, data preparation, entry, translation and quality control, etc. Reproduction, travel and other direct and indirect costs should also be included.

It is the responsibility of the Respondent to verify any count information used in estimating the cost of conversion. These estimates are based on the most current information available.

The following firm fixed cost worksheet should be filled out as a minimum. ***The worksheet must be accompanied by the non-collusion affidavits found in Appendix J - Forms***.

SPB

10.1 Firm fixed Unit Costs: Appendix B – Digital Color Orthoimagery (TIFF)

City of Edmond (110 miles @ 3")	$37,536.44
City of Choctaw (35.2 miles @ 6")	$2,378.14
City of Del City (8 miles @ 3")	$2,729.92
Midwest City (53 miles @ 3")	$18,085.74
OR (53 miles @ 6")	$3,580.72
(7 miles @ 3")	$2,388.68
(7 miles @ 6")	$472.93
City of Moore (21.9 miles @ 6")	$1,479.58
City of Norman (164 miles @ 6" and 92 miles @3")	$42,474.08
Oklahoma County (approx.. 520 miles @ 6")	$35,131.59

Optional mosaic products:

1. Mr SID and JP2000 of City of Edmond	Included
2. Mr SID and JP2000 of Choctaw	Included
3. Mr SID and JP2000 of City of Del City	Included
4. Mr SID and JP2000 of City of Midwest City	Included
5. Mr SID and JP2000 of City of Moore	Included
6. Mr SID and JP2000 of City of Norman	Included
7. Mr SID and JP2000 of Oklahoma County	Included
8. Mr SID and JP2000 of Entire Project Area - ACOG	Included

10.2 Optional Mapping Deliverables

City of Edmond

Planimetric Change Detection & Collection - Pilot Study Area Cost	$3,863.83
Planimetric Change Detection & Collection - Remainder of the City	$34,774.48
Change Detection, Collection and interpolation of the HE-DTM into 1 foot Contours- Pilot Area	$2,549.70

Change Detection, Collection and interpolation of the HE-DTM into 1 foot Contours - Remainder of the City $22,947.28 SPB

City of Choctaw

Hydrologically Enforced Digital Elevation Model (HE-DEM), Digital Terrain Model (DTM) and 2' elevation contours. $11,371.55

Planimetrics - hydrography-linear and polygon features including: street Centerlines, train tracks, building footprints, edge of pavement, sidewalks, Crosswalks and vegetation. $10,558.39

Midwest City

Digital Terrain Model (DTM)	$400.00
7' X 10' color wall map	$1,000.00
3.5' X 5' color wall map	$500.00

Moore

Planimetrics - hydrography-linear and polygon features including: street Centerlines, train tracks, edge of pavement, sidewalks, Crosswalks and parking lots. $8,255.56

Hydo-flattened bare-earth raster digital elevation model (DEM). $9,836.32

Norman

Planimetrics – 82 miles @ 1"=50' and 115 miles @ 1"=100' including: streets, pavement, unpaved parking and driveways, existing train tracks, building outlines, fences, sidewalks, and vegetation. $67,495.86

Option to add Height to Buildings $19,316.84

Hydo-flattened bare-earth raster digital elevation model (DEM). $5,284.12

DTM ASCII file in TIN generate format, ESRI 10.1 format $800.00

Geodatabase of topographic contours at 1' intervals (lines) in urban area and 2' intervals in rural and spot elevations (points) with attributes for elevation. $11,109.82

Breaklines $3,472.95

Raw Point Cloud fully compliant to LAS 1.4 $29,799.06

In addition, the Respondent may propose alternative pricing methods per Section 8.13. The participating agencies of COAGA 2015 reserve the right to limit the scope of the project.

10 **Cost Proposal Forms:** The COAGA 2015 is seeking firm fixed prices for the performance and delivery of digital orthoimagery and flight plan map. Prices shall cover all necessary work, materials, supplies, data preparation, entry, translation and quality control, etc. Reproduction, travel and other direct and indirect costs should also be included.

It is the responsibility of the Respondent to verify any count information used in estimating the cost of conversion. These estimates are based on the most current information available.

The following firm fixed cost worksheet should be filled out as a minimum. ***The worksheet must be accompanied by the non-collusion affidavits found in Appendix J - Forms***.

10.1 Firm fixed Unit Costs: Appendix B – Digital Color Orthoimagery (TIFF) SPP

City of Edmond (110 miles @ 3")	$26,290.34
City of Choctaw (35.2 miles @ 6")	$1,714.52
City of Del City (8 miles @ 3")	$1,912.02
Midwest City (53 miles @ 3")	$12,667.16
OR (53 miles @ 6")	$2,581.51
(7 miles @ 3")	$1,673.02
(7 miles @ 6")	$340.95
City of Moore (21.9 miles @ 6")	$1,066.70
City of Norman (164 miles @ 6" and 92 miles @3")	$29,976.37
Oklahoma County (approx.. 520 miles @ 6")	$25,328.07

Optional mosaic products:

1. Mr SID and JP2000 of City of Edmond	Included
2. Mr SID and JP2000 of Choctaw	Included
3. Mr SID and JP2000 of City of Del City	Included
4. Mr SID and JP2000 of City of Midwest City	Included
5. Mr SID and JP2000 of City of Moore	Included
6. Mr SID and JP2000 of City of Norman	Included
7. Mr SID and JP2000 of Oklahoma County	Included
8. Mr SID and JP2000 of Entire Project Area - ACOG	Included

10.2 Optional Mapping Deliverables

City of Edmond

Planimetric Change Detection & Collection - Pilot Study Area Cost	$1,888.32
Planimetric Change Detection & Collection - Remainder of the City	$16,994.85
Change Detection, Collection and interpolation of the HE-DTM into 1 foot Contours- Pilot Area	$1,734.52

SPA

Change Detection, Collection and interpolation of the HE-DTM into 1 foot Contours - Remainder of the City $15,610.69

City of Choctaw

Hydrologically Enforced Digital Elevation Model (HE-DEM), Digital Terrain Model (DTM) and 2' elevation contours. $11,371.55

Planimetrics - hydrography-linear and polygon features including: street Centerlines, train tracks, building footprints, edge of pavement, sidewalks, Crosswalks and vegetation. $5,927.33

Midwest City

Digital Terrain Model (DTM) $400.00
7' X 10' color wall map $1,000.00
3.5' X 5' color wall map $500.00

Moore

Planimetrics - hydrography-linear and polygon features including: street Centerlines, train tracks, edge of pavement, sidewalks, Crosswalks and parking lots. $5,335.67

Hydo-flattened bare-earth raster digital elevation model (DEM). $9,836.32

Norman

Planimetrics – 82 miles @ 1"=50' and 115 miles @ 1"=100' including: streets, pavement, unpaved parking and driveways, existing train tracks, building outlines, fences, sidewalks, and vegetation. $33,405.15

Option to add Height to Buildings $9,832.67

Hydo-flattened bare-earth raster digital elevation model (DEM). $2,794

DTM ASCII file in TIN generate format, ESRI 10.1 format $800.00

Geodatabase of topographic contours at 1' intervals (lines) in urban area and 2' intervals in rural and spot elevations (points) with attributes for elevation. $6,215.31

Breaklines $1,836.33

Raw Point Cloud fully compliant to LAS 1.4 $23,029.07

In addition, the Respondent may propose alternative pricing methods per Section 8.13. The participating agencies of COAGA 2015 reserve the right to limit the scope of the project.

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

__Susan Passon-Alexander____, of lawful age, being first duly sworn, on oath says, that (s) he is the agent authorized by the bidder to submit the attached bid. Affidavit further states that the bidder has not been a party to any collusion among bidders in restraint to freedom of competition by agreement to bid at a fixed price or to refrain from bidding; or with any city official or employee as to quantity, quality, or price in the prospective contract, or any other terms of prospective contract; or in any discussion between bidders and any city official concerning exchange of money or other thing of value for special consideration in the letting of a contract; that the bidder/contractor has not paid, given or donated or agreed to pay, give or donate to any officer or employee of the City of Edmond, Oklahoma any money or other thing of value, either directly or indirectly, in the procuring of the award of a contract pursuant to this bid.

The Sanborn Map Company, Inc.
Bidder

By: ______________________

Subscribed and sworn to before me on this 16th day of December, 2014

______________________ My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

Choctaw

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

__Susan Passon-Alexander__, of lawful age, being first duly sworn, on oath says, that (s) he is the agent authorized by the bidder to submit the attached bid. Affidavit further states that the bidder has not been a party to any collusion among bidders in restraint to freedom of competition by agreement to bid at a fixed price or to refrain from bidding; or with any city official or employee as to quantity, quality, or price in the prospective contract, or any other terms of prospective contract; or in any discussion between bidders and any city official concerning exchange of money or other thing of value for special consideration in the letting of a contract; that the bidder/contractor has not paid, given or donated or agreed to pay, give or donate to any officer or employee of Choctaw, Oklahoma any money or other thing of value, either directly or indirectly, in the procuring of the award of a contract pursuant to this bid.

The Sanborn Map Company, Inc.
Bidder

By: ______________________

Subscribed and sworn to before me on this 16th day of December, 2014

____

My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

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COUNTY OF___El Paso__________)ss

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The Sanborn Map Company, Inc.
Bidder

By: Susan P Alexander

Subscribed and sworn to before me on this 16th day of December, 2014

Emma [signature]

My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

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The Sanborn Map Company, Inc.
Bidder

By: [signature]

Subscribed and sworn to before me on this 16th day of December, 2014

[signature] My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

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The Sanborn Map Company, Inc.
Bidder

By: [signature]

Subscribed and sworn to before me on this 16th day of December, 2014

[signature]

My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

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The Sanborn Map Company, Inc.
Bidder

By: [signature]

Subscribed and sworn to before me on this 16th day of December, 2014

[signature] My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

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The Sanborn Map Company, Inc.
Bidder

By: Susan R Alexander

Subscribed and sworn to before me on this 16th day of December, 2014

Emma S [signature]

My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017

General

AFFIDAVIT OF NON-COLLUSION

STATE OF __Colorado__________)

COUNTY OF___El Paso__________)ss

____Susan Passon-Alexander__, of lawful age, being first duly sworn, on oath says, that (s) he is the agent authorized by the bidder to submit the attached bid. Affidavit further states that the bidder has not been a party to any collusion among bidders in restraint to freedom of competition by agreement to bid at a fixed price or to refrain from bidding; or with any official or employee as to quantity, quality, or price in the prospective contract, or any other terms of prospective contract; or in any discussion between bidders and any official concerning exchange of money or other thing of value for special consideration in the letting of a contract; that the bidder/contractor has not paid, given or donated or agreed to pay, give or donate to any officer or employee of Central Oklahoma Alliance of Government Agencies 2015 any money or other thing of value, either directly or indirectly, in the procuring of the award of a contract pursuant to this bid.

The Sanborn Map Company, Inc.
Bidder

By: Susan P Alexander

Subscribed and sworn to before me on this 16th day of December, 2014

Emma ______________________ My Commission Expires 30 June 2017

EMMA S NORTHUP
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID # 20094020968
MY COMMISSION EXPIRES JUNE 30, 2017