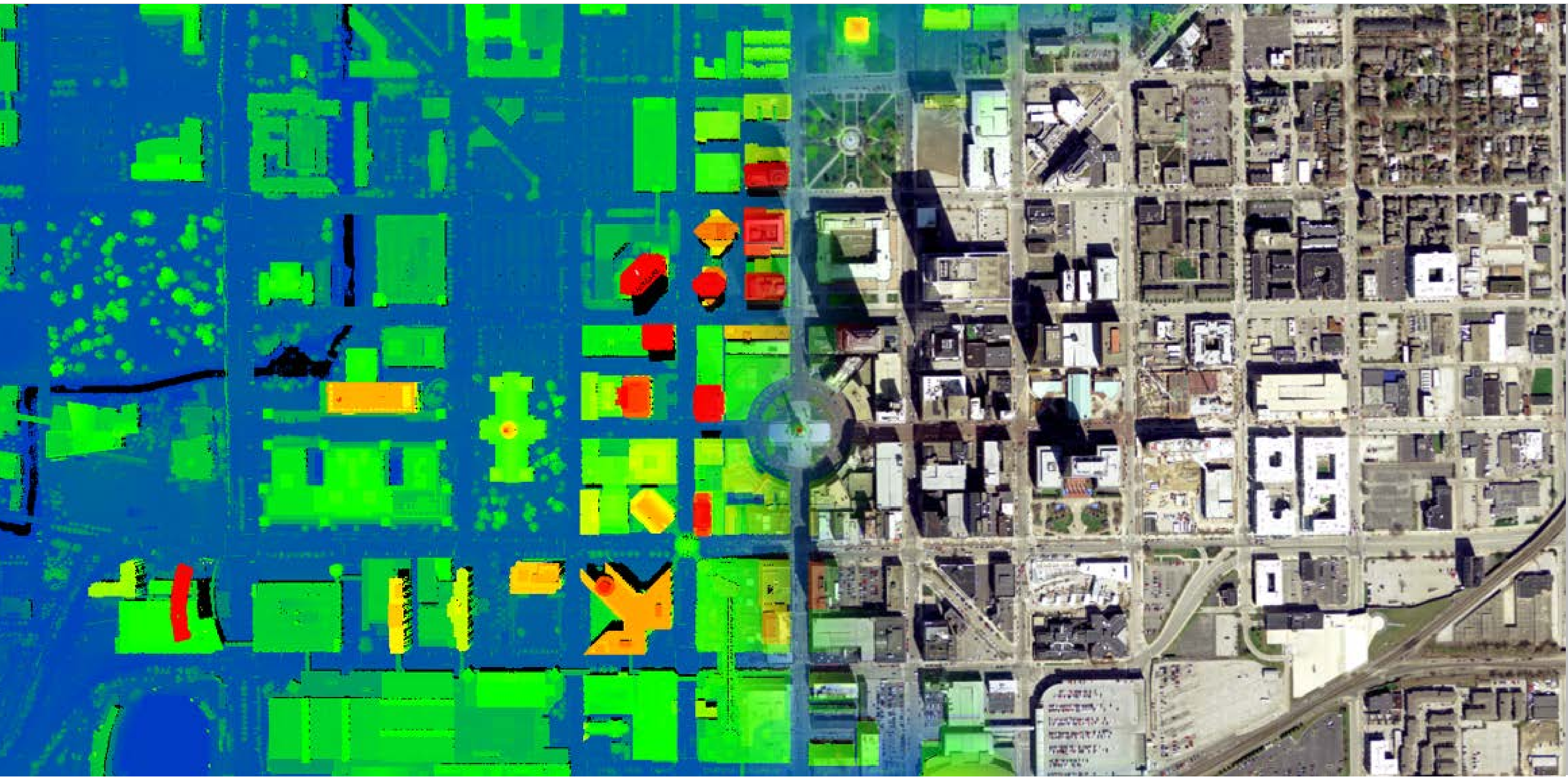
State of Indiana • Indiana Department of Administration (IDOA)

Indiana Orthoimagery and Elevation Program

RFP 24-76258 | February 14, 2024



Technical Proposal

WOOLPERT
ARCHITECTURE | ENGINEERING | GEOSPATIAL

Addendum # 1

RFP 24-76258
TECHNICAL PROPOSAL
ATTACHMENT F

Instructions: Please supply all requested information in the areas shaded yellow and indicate any attachments that have been included to support your responses.

Please provide a yes/no (Y/N) in the light blue shaded area, indicating your ability to meet requirements. If an item is left blank, you will be implying that your company cannot meet the requirement(s), and your proposal may be eliminated from evaluation. These Minimum Requirements will be used to evaluate respondents as described in Section 3.2 (Evaluation Criteria), Step 1.

Item	Requirement Description	Respondent Answer
1	Confirm your ability to complete the specifications, outlined in Attachment N.	Y
2	The Respondent shall guarantee that imagery or files which are not to specification, shall be fixed or replaced at no charge to IOT for at least four years after the date of delivery to IOT. Confirm your agreement.	Y

1 General Requirements and Definitions

1.1 Please list any additional terms and definitions used by your company or industry that you would like the State to consider incorporating in the contract. The State will not accept terms and definitions introduced after award during contract finalization and implementation.

Woolpert does not have any additional terms or definitions for the State's consideration.

1.2 Please confirm you have carefully reviewed all requirements listed in RFP Section 1.4. Should your company have any exceptions, substitutions, or conditions for the State's consideration, please list them below. The State will not accept exceptions, substitutions, or conditions introduced after award, during contract finalization and implementation.

Woolpert agrees with all requirements listed in RFP Section 1.4 with no exceptions, substitutions, or conditions for the State's consideration.

2 Background and Experience

2.1 Provide information that explains how your company has been involved with the GIS community in states where you have contracts and how you would plan to be involved in Indiana, if you are not already.

Woolpert employees remain active in several of Indiana Geographic Information Council's (IGIC) committees including Conference, Education and Outreach, Elevation, Indiana GIS Response Corps, Legislative, Orthophotography and Awards Committee. For this program, the following individuals make up our Woolpert Management Team:

- Ryan Bowe, GISP, PMP is our team's designated Project Manager. Ryan has been active on the IGIC Conference Committee for the past four years. She is recognized by the Indiana GIS community and will take office as the IGIC President later this year.

- Brian Stevens, CP, GISP is our team's Program Director and will support Ryan by helping promote the imagery and lidar program. Brian will focus on outreach and stakeholder involvement.
- Matt Worthy is our team's Production Manager and will support Ryan by managing staff resources, production, scheduling, quality control, and subcontractors.
- Mike Venegas is our team's Quality Control Manager and will support the program by overseeing adherence of our ISO Quality Standards.

For the 2005, 2011-13 and 2016-2018 Indiana Statewide Orthoimagery programs, Woolpert participated in the Program Development and Outreach. We provided program website development to support public access to program information and communicate various aspects of the program and exchange data via the internet; provided a statewide direct mailing and email campaign; provided seminars at various venues throughout the state to describe the benefits and return on investment (ROI) concerning the IOT program (product, services, cost information to county representatives, etc.); and provided as-needed individual representative follow-up meetings at various locations throughout the state.

To add validity to our experience and completion with large statewide and/or areawide collections, Woolpert has collected and processed approximately 419,000 square miles (comprised of 61 individual task orders) of aerial lidar under the USGS GPSC 3 contract and recently collected and processed approximately 75,000 square miles (comprised of 20 individual task orders) to date under GPSC 4. Task orders on both contracts are comprised of lidar data acquisition (topographic, bathymetric, and single photon), data processing, and data QA/QC at various nominal pulse spacing (NPS) at multiple geographic locations involving a range of technical requirements. In addition, Woolpert has been the geospatial vendor for the Ohio Statewide Imagery Program (OSIP) since 2006, producing more than 120,000 square miles of base orthoimagery and 80,000+ square miles of aerial lidar being, along with 100,000+ square miles of county/municipal buy-ups over this same timeframe.

Woolpert is providing, **as a separate attachment (Local Government Outreach),** our detailed contributions and involvement in various GIS communities in the State where we have current projects underway.

2.2 Describe your previous experience with dual statewide orthoimagery and lidar projects.

The Woolpert team has been performing large regional and statewide programs for over 20 years. Currently, Woolpert is the lead contractor on five multi-year statewide programs and has been a valued subcontractor on four additional multi-year statewide initiatives, while also supporting projects covering thousands of square miles for the USGS and NOAA annually.

A recent example of Woolpert's experience with dual statewide orthoimagery and lidar projects is the work we have performed for the state of Ohio (Ohio Geographically Referenced Information Program). The OGRIP program is comprised of statewide 6-inch orthoimagery, statewide 3DEP QL1 8 ppsm aerial lidar, along with several county enhanced imagery and lidar (greater point density) buy-ups.

Woolpert's project approach is based on the following:

- Intimate knowledge gained from the successful completion of past state of Indiana programs (FY 2011-13, 2016-18) along with the regional/county/municipal projects.
- Knowledge gained from the successful completion of statewide programs, federal projects, and local/regional/county/municipal projects.
- Implementation of new, proven aerial imagery and lidar acquisition, data processing, data extraction technology performed on similar projects.
- Advancements in production workflow allowing for increased productivity and accuracy while reducing cost and turnaround time.

A program of this magnitude requires vast resources, experience, and knowledge. Ryan Bowe, GISP, PMP brings a wealth of knowledge and experience about geospatial activity in the state of Indiana. Her involvement in the last Indiana Statewide Imagery Program (along with Kent Park, Woolpert Program Director at the time) provided her the insight needed to make this program successful. A majority of our lidar and orthoimagery staff are still active and available to continue work on the Indiana Statewide Program.

Our enhanced team approach will provide the most accurate and cost-effective data in support of the State's program and will comply with Woolpert's ISO 9001:2015 quality management program.

2.3 What complications, if any, do you anticipate given that this project, while being a seamless statewide project, will be managed as 3 (three) 1-year projects and delivered county-by-county?

Woolpert's involvement on previous Indiana statewide orthoimagery projects required us to deliver seamless statewide data across jurisdictional boundaries, and multiple resolutions of imagery, captured over several years. While we are not able to control the weather during the acquisition season, we take advantage of powerful computing algorithms to establish consistent radiometric settings including color balancing, overall tone, dodging, brightness, and contrast. For the first and each subsequent collection year, Woolpert will provide a data sample of urban, rural, agricultural, forest, and wetland areas to the State for review and approval of the radiometric settings.

We understand some government agencies may want to acquire imagery outside of their respective tier acquisition year. Our team has sufficient aircraft and sensor resources to accommodate such requests. Furthermore, we do not foresee any complications of this project being a multi-year, county-by-county deliverable to achieve the state's goal of a seamless statewide dataset.

2.4 How many aircraft outfitted with the same family of sensor are you able to make available for this project each year?

For the base program, Woolpert is committing two aircraft, along with the associated aerial imagery and lidar sensors. These aircraft, configured with dual ports for simultaneous data collections (as shown below), are outfitted with computer control navigation systems (CCNS) and multiple aerial data sensor systems – all equipped with GPS/GNSS/IMU technology. All aircraft are maintained and operated under FAA regulations.

For the base Indiana Statewide Program, Woolpert will utilize the following aerial sensors:

Imagery—two Leica DMC-4 airborne imaging sensors.

Lidar—two high point density Zeus sensors.

These sensors are innovative, high-altitude collection devices improving both collection time and efficiency.

In addition to Woolpert dedicating two aircraft and two sets of aerial sensors, we have brought on our teammate Keystone Aerial Survey's Inc. to provide capacity for out-of-cycle buy-ups. Keystone operates Leica DMC-3 airborne imaging sensors, as well as Leica CityMapper aerial lidar sensors. This strategy supports all aspects of aerial acquisition for each flying season.

In the event an aircraft is offline due to equipment or maintenance, both Woolpert and Keystone operate a fleet of aircraft (Woolpert's fleet: 8 aircraft; Keystone's fleet: 30 aircraft) and have the ability to swap out aerial sensors to other aircraft to prevent any missed data collection opportunities.

Woolpert Aircraft Showing Dual Ports

Indiana Flight Plan

In accordance with our flight planning process depicted below, prior to our resource deployment, Ryan Bowe, along with Matt Worthy will meet with the flight acquisition and survey managers to review the specifications and requirements, initial flight plans, equipment, base station locations, survey schedules and points of contact to establish air-to-ground communications protocols.

Phase 1	Phase 2	Phase 3	Phase 4
• Review task order specifications • Review and validate AOI • Access collection AOI (terrain, features, airspace, etc.)	• Determine sensor type • Obtain appropriate airspace approvals and schedules	• Develop final flight Organize flight resources • Review/validate flight plan	• Obtain client approval • Develop data collection schedule

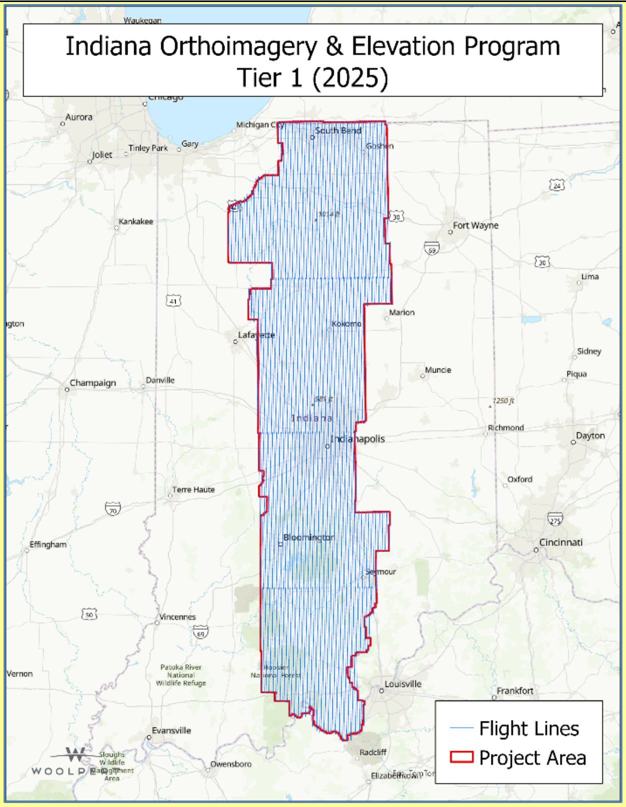
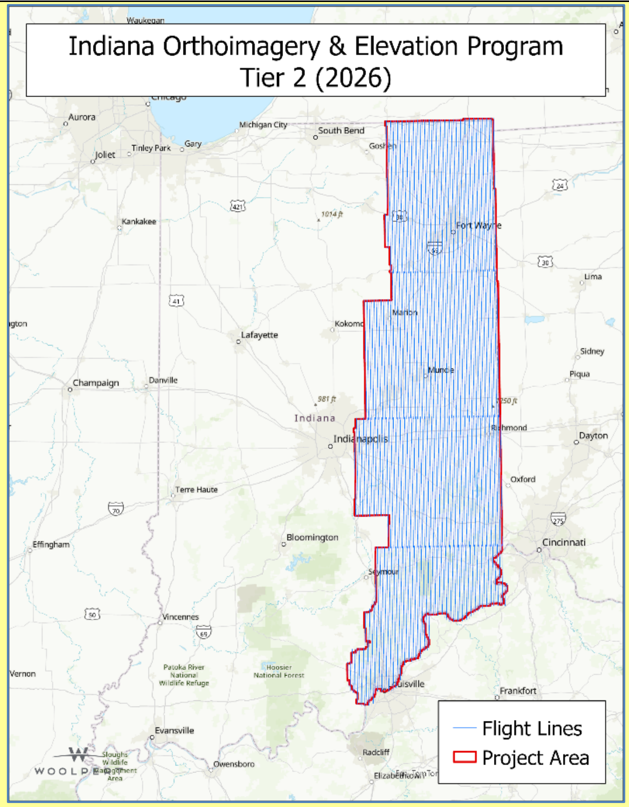
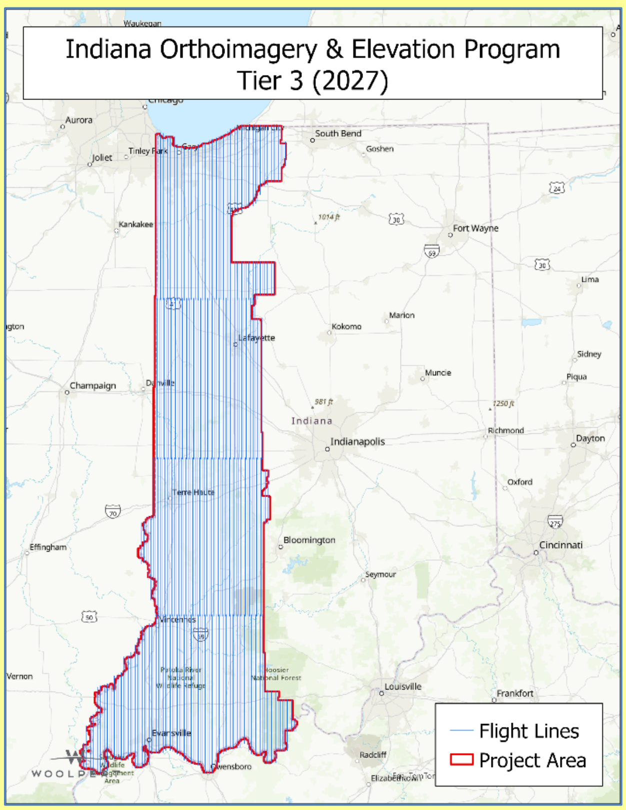
The flight acquisition team will review the area of interest (AOI) and develop a flight plan that maximizes the capability of our airborne system while meeting project requirements. Flight planning parameters will depend on pixel resolution; satellite visibility affecting the geometric dilution of precision (PDOP) of GPS/GNSS; location of Continuously Operating Reference Stations (CORS); local weather conditions; sun angle; leaf on/off conditions; terrain of relief; urban areas with tall buildings; and possible airspace restrictions. The flight team will evaluate the range of terrain relief to determine the optimal flight planning parameters for the collection area, with considerations for sensor parameters.

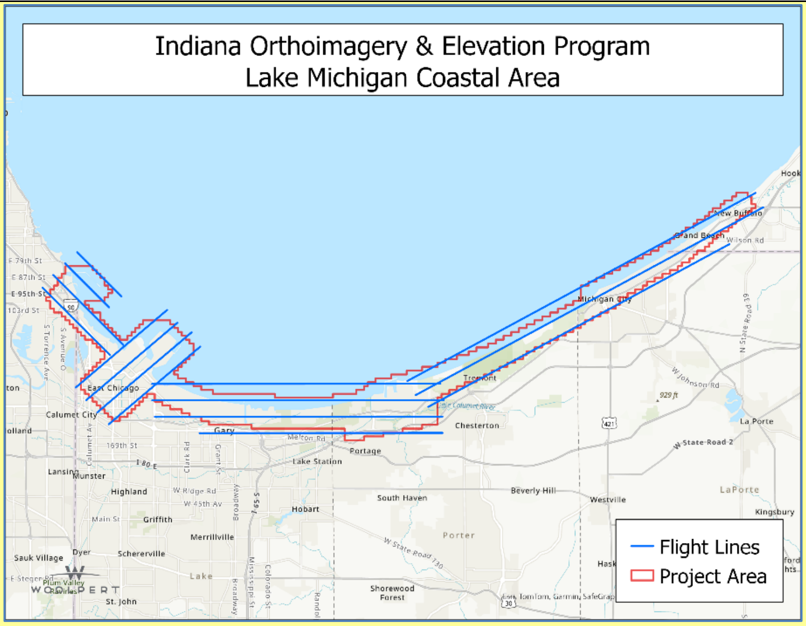
Airborne Data Acquisition. The flight acquisition team will perform pre-flight reviews of all flight maps, sensor parameters, and project requirements (vegetation and ground conditions, sun angle,). All flight planning files (flight navigation system and the sensor’s flight management control system) get loaded and confirmed. Once the weather over the project area is confirmed suitable for airborne data acquisition, the flight crew and/or surveyor will establish the airborne GPS base station over a known, published control station, and the flight crew will prepare for flight. The pilot will perform all pre-flight aircraft safety procedures prior to takeoff while the sensor operator verifies the airborne sensor and project parameters. Prior to takeoff, GPS will be initialized and logged while the aircraft is in static mode on the ground. Once airborne, prior to data capture, an S curve or figure eight will be flown to initialize the IMU.

After completion of each airborne data acquisition mission, the flight crew will immediately download the aerial data to multiple external hard drives. A master copy is kept with the flight team in a secured location and a copy is shipped to the appropriate Woolpert office teaming partner processing facility or on-site data processing facility in preparation for immediate processing and quality control reviews. GPS and IMU data get processed and validated. The technician will then perform an initial data reduction on the airborne dataset for a rigorous quality control analysis to check for completeness and any anomalies such as atmospheric conditions (smoke, fog, clouds, haze, or standing water, etc.), sensor-related issues, data gaps (data voids between flight lines). If anomalies are found, edit calls will be documented and the flight team will be notified immediately to schedule re-flights.

Flight Plan Specifications

- Flying Altitudes .... 9,100’-10,000’ AGL
- Average Ground Speed .... 160-180 knots
- Forward Lap 60%
- Side Lap 30%
- ABGPS .... Base Station and CORS
- Camera System 1 .... Orthoimagery: Leica DMC-4
- Lidar System 1 .... Aerial Lidar: Zeus
- Output Resolutions .... Orthoimagery: 3-inch (7.5-cm) OR 6-inch (15-cm) | Lidar: 25 ppsm


Indiana Orthoimagery & Elevation Program
Tier 1 (2025)
Flight Lines
Project Area
Chicago
Aurora
Joliet
Tinley Park
Gary
Michigan City
South Bend
Goshen
Kankakee
Fort Wayne
Lima
Marion
Kokomo
Lafayette
Champaign
Danville
Muncie
Sidney
Piqua
Indiana
Indianapolis
Richmond
Dayton
Oxford
Terre Haute
Bloomington
Cincinnati
Effingham
Seymour
Vincennes
Louisville
Frankfort
Evansville
Owensboro
Radcliff
WOOLPERT

Indiana Orthoimagery & Elevation Program
Tier 2 (2026)
Flight Lines
Project Area
Chicago
Aurora
Joliet
Tinley Park
Gary
Michigan City
South Bend
Kankakee
Fort Wayne
Lima
Marion
Kokomo
Lafayette
Champaign
Danville
Muncie
Sidney
Piqua
Indiana
Indianapolis
Richmond
Dayton
Oxford
Terre Haute
Bloomington
Cincinnati
Effingham
Seymour
Vincennes
Frankfort
Evansville
Owensboro
Radcliff
WOOLPERT

Indiana Orthoimagery & Elevation Program
Tier 3 (2027)
Flight Lines
Project Area
Chicago
Aurora
Joliet
Tinley Park
South Bend
Goshen
Kankakee
Fort Wayne
Lima
Marion
Kokomo
Lafayette
Champaign
Danville
Muncie
Sidney
Piqua
Indiana
Indianapolis
Richmond
Dayton
Oxford
Terre Haute
Bloomington
Cincinnati
Effingham
Seymour
Vincennes
Louisville
Frankfort
Evansville
Radcliff



Please note: Our plan for Indiana revolves around co-collection of aerial imagery and lidar. Based on this co-collection, along with the imaging and lidar sensors onboard, we will provide statewide 3DEP QL1 lidar meeting an average high point density of 25 ppsm (for the same fee as 8 ppsm). Along with this increased lidar point density, we will simultaneously acquire 3-inch aerial imagery, which may be resampled to 6-inch, but more importantly can be processed natively providing statewide 3-inch ortho resolution. This unique approach options statewide 3-inch orthoimagery at an extremely competitive price and turnaround timeframe.

2.5 Please describe your ability to prioritize the acquisition of Indiana imagery within the flying season during clear weather conditions; include length of time aircraft will remain on-site.

Before each flying season is initiated, Ryan Bowe and Matt Worthy will meet with the Indiana team and review the particular year's base acquisition area, along with any city/county buy-ups. Area priorities will be discussed, and acquisition scheduling made with the flight crews for high-priority areas.

The size and shape of the proposed collection regions allow our flight crews to start with acquisition in the southern portion of the state, thus allowing for a south-to-north progression, which maximizes the acquisition window due to the likelihood of snow obscuring the ground in the northern portions of the state while snow free conditions exist in the south. This progression allows the aircraft to maximize leaf-off conditions in the southern areas of the state and advance north, as leaf-out in the northern portion of the state is several weeks later than the southern counties due to the geography and terrain within the state.

Before acquisition, Ryan Bowe, along with Matt Worthy, will review both the weather and ground conditions and consult with the Indiana team and other local contacts for that year's region to determine if conditions are favorable to begin (and throughout) acquisition. These discussions will continue until it is determined conditions are favorable and aircraft are mobilized.

With the Dayton, Ohio International Airport being the primary operational area for the Woolpert fleet of aircraft and within 50 miles of Indiana, prioritizing and mobilizing aircraft for the Indiana Imagery/Lidar Program will not be an issue. Our aircraft are within a 30-45-minute mobilization to any location within Indiana and will not miss an opportunity to acquire aerial data due to aircraft base location. When our aircraft do deploy to Indiana, they will remain on site until the environmental conditions no longer allow for production.

In this case, they may deploy back to our hanger at the Dayton International Airport, allowing them to easily deploy back to Indiana for the next flying weather window.

3 Core Deliverables

3.1 Aerial 4-band Digital Orthoimagery

3.1.1 Explain your ability to complete the specifications outlined in Section 7.1.1 of Attachment N.

With 20+ years of statewide orthoimagery production, Woolpert's approach to all successful aerial 4-band digital orthoimagery programs is founded on adequate project and mission planning.

Woolpert has reviewed the specifications in Attachment N section 7.1.1 and, having completed several statewide projects with similar specifications including the previous 2011-2013 and 2016-2018 Indiana projects, is ready to deliver your specifications on-time and within budget.

Woolpert will complete the specification requirements as shown below:

- 4-band (RGB+NIR).
- 32-bit with 8-bit unsigned pixel depth per band.
- ASPRS Class 1 accuracy.
- 30° or greater sun angle.
- Free of snow, cloud shadows, atmospheric haze, sun glare reflections, excessive moisture.
- Full 2,500' x 2,500'-foot grid tiles without "no-data" areas.
- Indiana State Plane East (EPSG 2967) or West (EPSG 2968) zone as appropriate, NAD83/HARN, U.S. survey feet.

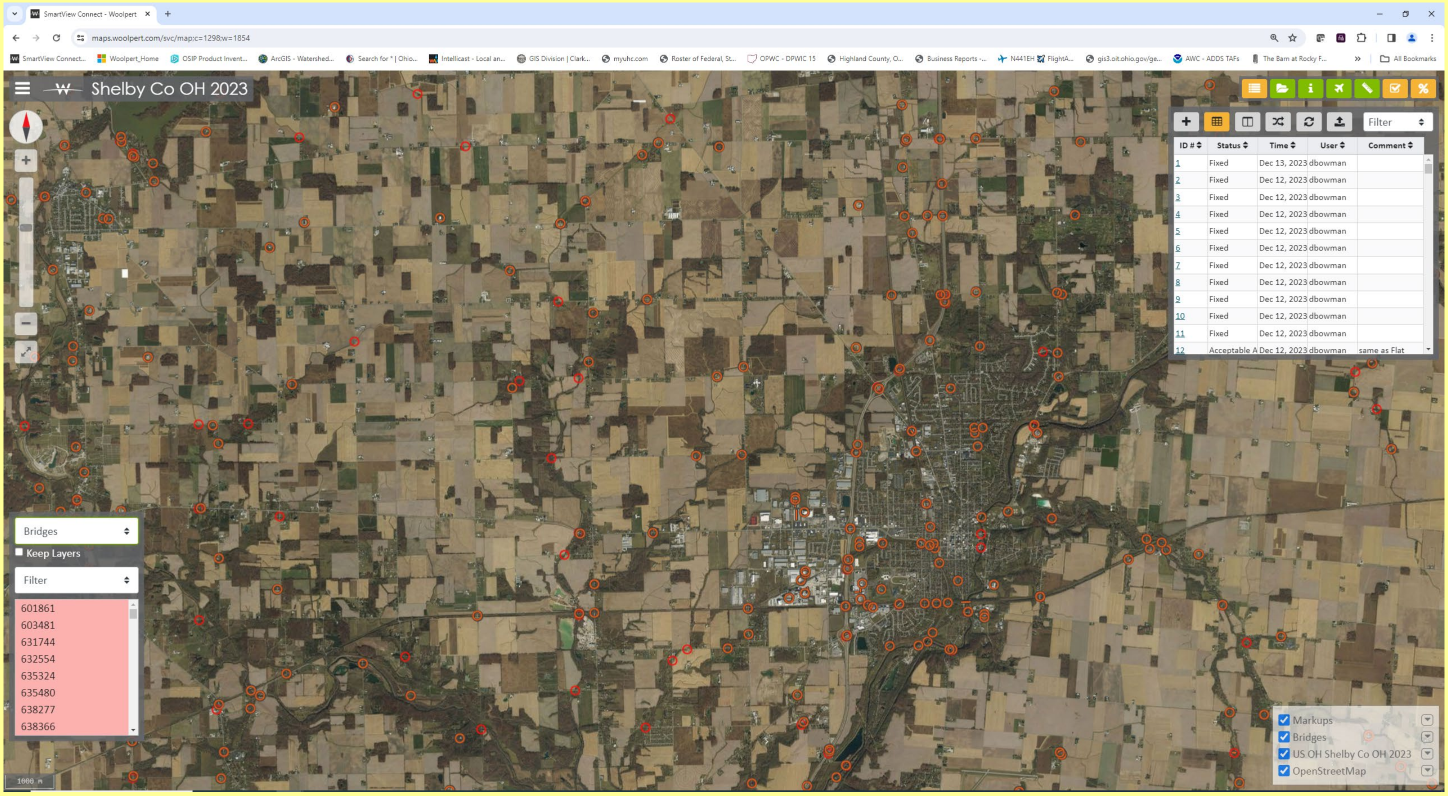
Woolpert understands the State's goal to acquire imagery for the entire state within a four-year program. We can support your focus on approximately one-third of the state flown each year in an ongoing rotation, in addition to the Lake Michigan shoreline area each year.

- Year one (2025): Tier 1 (central) + lakeshore.
- Year two (2026): Tier 2 (eastern) + lakeshore.
- Year three (2027): Tier 3 (western) + lakeshore.
- Year four (2028): lakeshore.

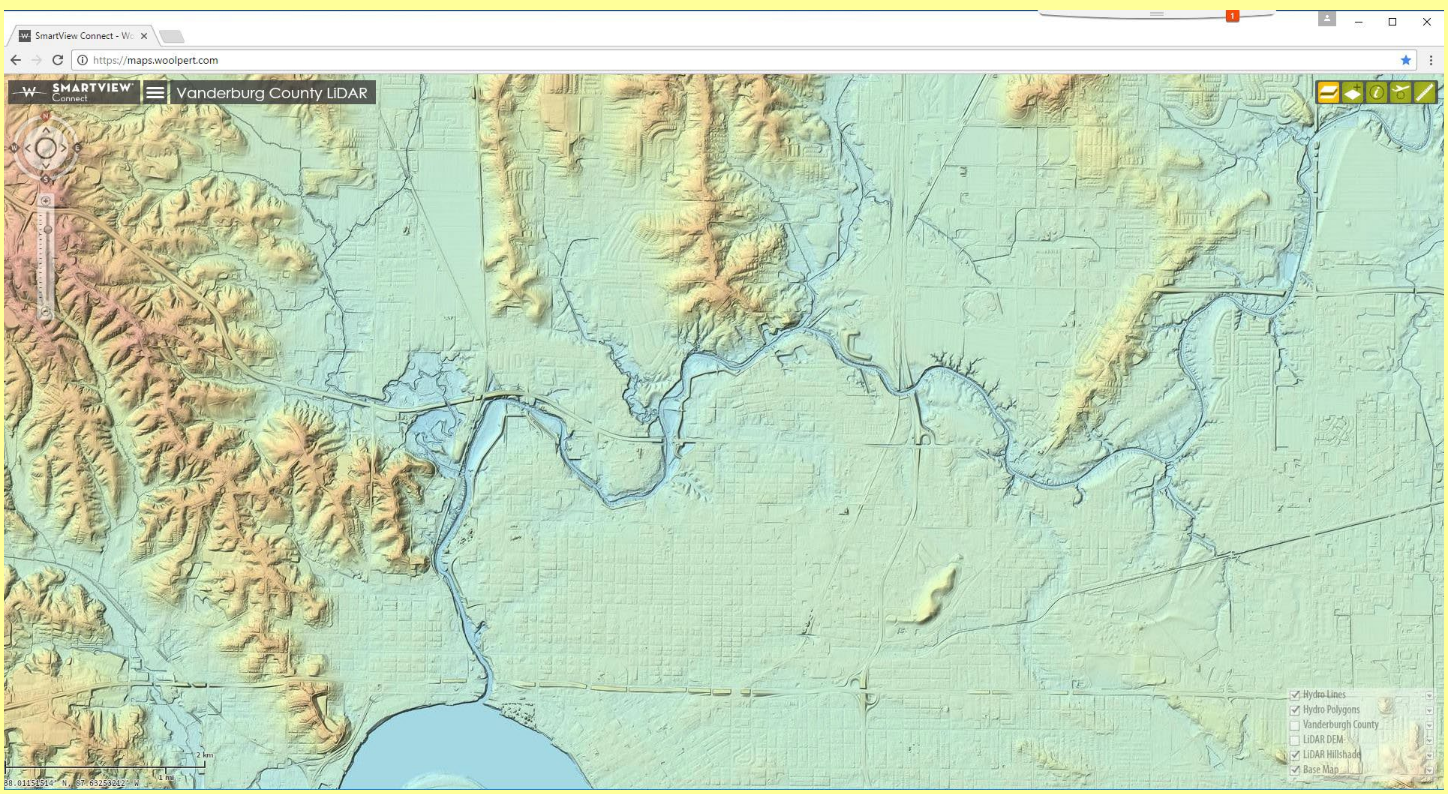
Additional project partners, including counties, municipalities, townships, and others, may buy-up to higher pixel resolutions with the same specifications, either in or out of the State's tier system cycle.

Woolpert's orthoimagery processing takes advantage of powerful computing algorithms to establish consistent radiometric settings including color balancing, overall tone, dodging, brightness, and contrast. For the first and each subsequent collection year, Woolpert will forward a representative sample of urban, rural, agricultural, forest and wetland areas to the State for review and approval of the radiometric settings prior to orthoimagery production commencement. The agreed upon settings will be applied to all subsequent imagery deliverables.

Woolpert's proprietary SmartView® Connect (SVC) platform and built-in web-based redline tool is capable of hosting large imagery, raster, and vector datasets to facilitate efficient response from clients for rapid delivery and review of collected data. Our SVC website can host terabytes of geospatial data, displaying the imagery along with relevant reference datasets, and provides tools for redline markups and workflow management. SVC has been utilized by the state of Indiana during the previous Woolpert orthoimagery projects to profound effect. Nevertheless, Woolpert staff will meet with State and partner staff early each year to review how SVC works and establish editing and review guidelines.



The above image illustrates SVC's design as an online redlining tool, used internally by Woolpert production staff and provided to our clients for their own review and markup. In the photo example above, SVC showcases the areas of correction by our production staff.



Not only can SVC be used for orthoimagery, but it can also be utilized to provide review of a lidar DEM/shaded relief map.

Woolpert has added experience in various methods for cloud delivery including Amazon, Azure, Google, and even our own proprietary Open Geospatial Consortium (OGC)-compliant Web Map Service (WMS)/Web Map Tile Service (WMTS) platform known as STREAM:RASTER™. It allows secure customization of the site as well as methods for quality control and upload/download monitoring. Additionally, we can set-up an individual account for each participating entity so we can control who has access to the data and monitor download events.

3.1.2 In the past five years, have any final deliverables for statewide orthoimagery projects been rejected by the client, and if so, how did you resolve these issues?

Woolpert has not had any statewide orthoimagery projects rejected in the last five years. This is a testament to our Quality Management System (QMS) implementation and encouragement of pilot deliverables such as those required by your Orthoimagery and Elevation Program. Throughout the last Indiana Statewide Program, Woolpert worked with the State and local entities to identify and resolve issues of concern, from acquisition through final products. We understand the complexities of flying in Indiana airspace and the challenges it can bring during the acquisition season. From the snow in the north, to the flooding in the south, we make every effort to anticipate geographical and meteorological challenges before they occur. Woolpert's project manager will work with the State or its representatives proactively to review concerns and develop a joint resolution.

3.1.3 How do you propose to manage the overlap area between counties of different resolutions (one county is acquired as 3 inch adjacent to a county that is 6 inch)?

In a situation with two adjoining counties of different resolutions, each county will receive their intended pixel resolution covering their county's boundary, plus a 100-ft extended buffer. Where the extended buffer touches a delivery tile, a full tile will be produced with image coverage. This method will ensure each county will have coverage at their intended resolution and not confuse imagery resolution collection within one counties boundary. This method will ensure full overlap of imagery outside each county's boundary.

This approach also provides a seamless transition between adjacent areas acquired in the same year with different final pixel resolutions, as the original 3-inch pixel imagery will be resampled to a 6-inch pixel resolution where needed. Also, Woolpert flight planning will ensure imagery sidelap between the tiers acquired annually, to provide a tie-edge of imagery between counties.

3.1.4 What issues do you anticipate with color balancing a project that spans multiple years, and what process do you use to mitigate any issues?

With more than one million square miles of imagery acquired in multiple statewide programs over the last 20 years, Woolpert recognizes the most critical factor in color balancing starts with the aerial survey itself. Our acquisition team understands consistent conditions such as sun angle and vegetation throughout the program result in the best overall color balancing. While impossible to control the weather or the length of each flying season, Woolpert's acquisition team has developed specific planning and monitoring tools proven successful for wide area collections over multiple years.

Once imagery is acquired and aerial triangulation is completed, our imagery specialists import the entire county/statewide dataset into specially designed software for viewing aerial imagery. The specialists run through a three-step review process to determine the best approach to mitigate appearance differences:

1. Review the imagery histogram and statistics to identify any unusual spikes or outliers.

2. Scan the imagery for features such as urban development, bodies of water, large forest, etc.
3. Review the darkest (shadows) and lightest (building roofs) features in the imagery.

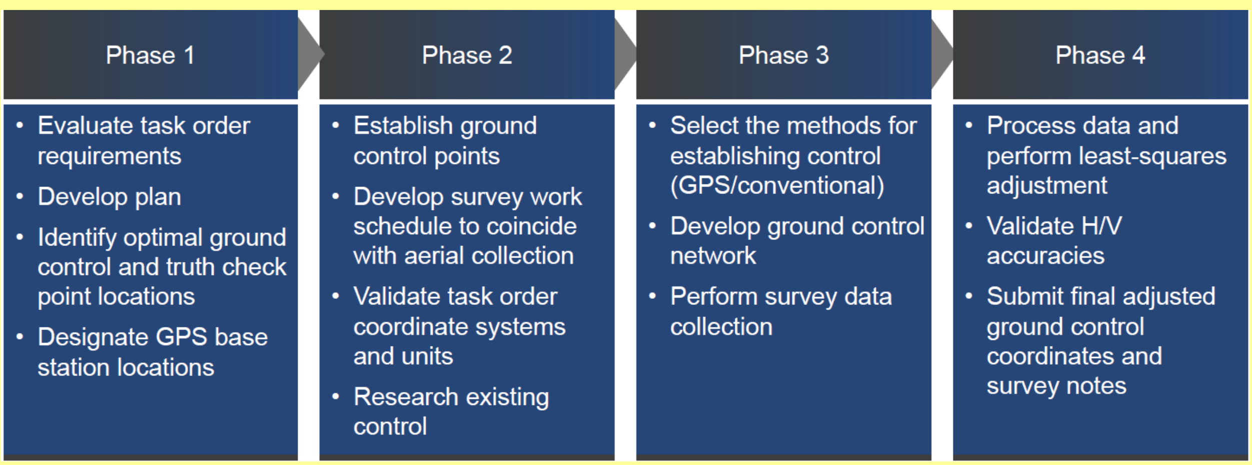
The imagery specialists may run through this process multiple times to find the right balance, by carefully reviewing the overall dataset and histogram while also observing the results to the previous year(s) imagery.

Before full orthoimagery production begins, a representative sample of urban, rural, agriculture, forest, and wetland areas will be submitted to the State for review and approval of radiometric settings, including color balancing, overall tone, dodging, brightness, and contrast. Image radiometry shall be agreed upon before deliveries commence. Each year, the first county delivered shall be used as a pilot to verify processing, radiometry, quality control, naming, and delivery. Image settings of subsequent deliverables will match this pilot, pending any verification corrections.

3.1.5 Describe your approach for establishing ground control of sufficient density and accuracy to meet the requirements of the deliverable orthoimagery at the resolutions indicated (Section 4 of Attachment N). Describe how you intend to perform required independent accuracy testing.

Having performed the ground control for the 2005, 2011-2013 and 2016-2018 Indiana statewide programs, Woolpert is in a unique position to perform the ground control for the 2025-2028 program. Bill Dougherty, PS, an Indiana licensed professional surveyor, will plan and oversee survey work performed as part of the 2025-2028 orthoimagery program. Mr. Dougherty has successfully supervised surveying services for numerous projects throughout the state of Indiana and the Midwest region.

The establishment of ground control points (GCP), airborne GPS base stations, check points for the data accuracy analysis, and other collection is necessary to support statewide data collection. The following depicts our systematic survey planning process.



Woolpert will incorporate all existing control into your project workflow, including the 2021-2024 statewide control and 24 counties' control from other projects that Woolpert has performed since 2005. If needed, new control points will be established. For new control points, the Woolpert team chooses to use Photo Identifiable (PID) points as often as possible. PID points are more environmentally friendly and prevent unnecessary public intrusion and community disruption. PID points will be picked on clear, well-defined locations photo identifiable from the imagery. The PID points will be semi-permanent locations, such as the intersection where the edge of a concrete driveway meets a concrete sidewalk. The new PID GCPs will be consistent with second order horizontal and third order vertical.

Our ground control survey steps include:

- Overlaying existing PID point locations onto new flight layouts to review proper distribution for required products.
- Overlaying existing PID points on newly acquired imagery to determine whether PID's are valid or removed/destroyed.
- Locating new/alternative points if existing PID points are no longer viable or destroyed.
- Producing a control diagram with existing and new points.
- Performing the survey field mission to perform GPS observations.
- Performing computations and generate coordinates.
- Producing a ground control survey report.

Woolpert will provide a survey report containing all the pertinent information required such as control diagrams, point descriptions and diagrams, log sheets, etc. We propose to reference the American Society for Photogrammetry and Remote Sensing (ASPRS) "Positional Accuracy Standards for Digital Geospatial Data, EDITION 2, VERSION 1.0" as the basis of the accuracy standards for the State's program. For horizontal accuracy, we conduct meticulous assessments using GCPs and reference data, adhering to the ASPRS/NSSDA standards with a minimum of two checkpoints per county. In buy-up areas, additional checkpoints are strategically placed to enhance scrutiny based on terrain characteristics. Similarly, for lidar vertical accuracy, our testing protocol adheres rigorously to the ASPRS standards, incorporating GCPs for calibration and independent checkpoints for the accuracy analysis. This comprehensive evaluation, meeting or exceeding specified standards, will be detailed in a final project report, providing you a clear understanding of the reliability and precision of our orthoimagery and lidar datasets.

3.1.6 ASPRS Accuracy Standards – Propose your approach and method to perform independent accuracy testing of the orthoimagery products as outlined in Sections 6 & 7 of Attachment N.

As stated in the ASPRS "Positional Accuracy Standards for Digital Geospatial Data, EDITION 2, VERSION 1.0" , the horizontal accuracy of the digital orthoimagery will be checked, measured, and tested against photo identifiable checkpoints. Woolpert will measure the primary horizontal accuracy of the digital orthoimagery in terms of $RMSE_H$—the combined linear error along a horizontal plane in the radial direction. For the state of Indiana, the digital orthoimagery will be produced to meet the ASPRS positional accuracy standards for 7.5-cm horizontal accuracy class, meaning the $RMSE_H$ for the resulting data set must be less than or equal to 7.5 cm. And for the case in areas of digital orthoimagery mosaics, there will be an additional criterion for the allowable mismatch at seamlines of $\leq 2^* RMSE_{H,} \leq 15.0$ cm. Woolpert imagery specialists will assess the horizontal accuracy of the digital orthoimagery in SVC. The horizontal accuracy of the digital orthoimagery will be reported accordingly in the final project reports and metadata.

3.1.7 Describe how existing control from the 2021-2024 Orthoimagery project, as provided by the State, may be incorporated; include any plans for determining the availability and/or quality of any other existing ground control.

As outlined in the response to Item 3.1.5 above, Woolpert will incorporate the existing 2021-2024 statewide control, and existing control from the 24 county projects Woolpert has performed since 2005, along with other existing control into your 2025-2028 project workflow. For additional control points, the Woolpert team will initially look to existing 2016-2020 lidar control which includes adequate x, y, and z information. Woolpert's previous control points were semi-permanent PIDs and, having established them, we will perform reconnaissance to verify the usability of each identified control point. If needed, new or additional control points will be established. A similar approach is anticipated for the 2025-2028 project's ground control survey requirements.

3.1.8 Describe your method for documenting and marking collected ground control points such that they can be relocated by other surveyors and survive throughout the timeframe of the project.

As previously stated, Woolpert will utilize PIDs GCP locations as often as possible. The PID points will be selected from clear, well-defined locations photo identifiable on the imagery. The PID points will be semi-permanent locations, such as the intersection where the edge of a concrete driveway meets a concrete sidewalk. The GCPs are planned to last the timeframe of the project, by using the edge of pavement, concrete, and other semi-permanent features. The new PID GCPs will be consistent with second order horizontal and third order vertical.

To aid in GCP recovery, photographs will be taken during the ground control survey.

- The photographs will be taken from each of the cardinal points (North, South, East, and West).
- The GPS survey equipment will be in view so that the surrounding environment is recorded with respect to the point location being collected.
- All photos will be taken during daylight hours.
- The photographs will be of sufficient spatial resolution to enable interpretation of terrain undulations and vegetative cover surrounding the point location for a minimum of 10 feet in all directions surrounding the point.
- Each photograph will be labeled in a way that includes the point's unique identifier.
- The required photographs will be delivered embedded in the ground control survey report.

3.1.9 Describe how horizontal and vertical control will be established and used based on proposed sensors, accuracy, collection techniques and processing.

The survey team will design a geometric and observation plan before performing GPS observations. Observations will be performed using experienced ground control survey field crews. The team will download and process the observation data daily. This will ensure the integrity of the network as it is constructed. As a daily quality control measure, field crews will process the data upon collection completion and re-observe any blunders or poor-quality lines as needed. It is anticipated this project may require the field crew to utilize a combination of three types of GPS survey techniques: Real Time Kinematics (RTK) GSP, Rapid-Static GPS, and/or the use of a Virtual Reference System (VRS) network. Woolpert will utilize RTK/VRS GPS surveying using cellular and or radio modems for measuring photogrammetric control stations and GCPs. Rapid-static GPS surveying will be utilized for those photogrammetric control stations and quality control check points located in areas where radio link or cellular coverage does not exist.

RTK GPS Survey. A Trimble Navigation R series GPS dual frequency receiver and a modem will be used for the RTK GPS base station(s). A Trimble Navigation R series dual frequency GPS will be used for roving measurements. Receivers with Trimble Navigation TSC3 data collector will be utilized. For this survey technique, we will use a 1-second epoch rate in fixed solution RTK mode with each observation lasting 60 to 180 seconds. Each photogrammetric control station will be observed twice.

Rapid-Static GPS Survey. This requires a minimum of two receivers to occupy stations at either end of a baseline for approximately 10-20 minutes, depending on the baseline length, number of satellites, and satellite geometry. This is similar in theory to static surveying; however, shorter observation time is made possible due to advances in both hardware and software. This project will utilize Trimble Navigation R series dual-frequency GPS receivers for the field data collection. Woolpert will use a minimum 15-second sync rate with each observation lasting between 20-40 minutes.

Horizontal and vertical control will be acquired using dual-frequency geodetic-grade GPS receivers. We propose to use GPS for both horizontal and vertical control. We base this recommendation on our recent successful projects that used the highest quality dual-frequency GPS receivers, utilizing the maximum number of satellites during our observation sessions and accurate geoidal modeling to determine accurate orthometric heights.

VRS or Real Time Network. The VRS concept is based on a network (spaced at 50-60 kms) of GNSS (GPS or GPS/GLONASS) reference stations permanently connected to the control center via the Internet. The networked stations collectively and precisely model ionospheric errors for the individual GNSS rover in the network coverage area. The rover interprets and uses the VRS network-correction data as if it is operating with a single physical base station on a noticeably short baseline, which increases the RTK performance. Corrections (vectors) come from the closest base, but because ionospheric error (which is traditionally baseline dependent) is practically negated, the rover's accuracy degradation due to baseline length starts when the rover is first initialized, i.e., at the work site. Thus, accuracies are increased and more consistent throughout the working region.

To support the lidar data production phase for Indiana's statewide program, Woolpert proposes to reference the ASPRS "Positional Accuracy Standards for Digital Geospatial Data, EDITION 2, VERSION 1.0" to determine the number and accuracy of check points used for the data accuracy analysis and validation. For the lidar data accuracy analysis testing, Non-vegetated Vertical Accuracy (NVA) points Vegetated Vertical Accuracy (VVA) points will be reviewed and recovered. New required checkpoints will be uniformly dispersed and surveyed within the State's annual tiers. The NVA and VVA GCPs will be used to perform an independent data accuracy analysis, as the check points will not be incorporated into Woolpert's vertical solution. The vertical accuracy of the lidar data will be reported accordingly in the project reports and metadata.

The NVA check points will provide the state of Indiana with a reliable assessment of the lidar surface model. They will be in open terrain, where there is a high probability that the sensor will have detected the ground surface without influence from the surrounding vegetation. The "open terrain" land cover checkpoints will be located on flat or uniformly sloping terrain and will be at least five meters away from any breakline where there is a slope change.

The checkpoint accuracy will meet or exceed a local network accuracy of 5-cm at the 95% confidence level. Woolpert will provide validation of survey accuracy. Within each classification type, check points will be distributed among all constituent land cover types in approximate proportion to the areas of those land cover types. The most common NVA land cover categories are bare earth/open terrain and urban. The most common VVA land cover categories are (tall weeds/crops, brushland and trees, and forested/fully grown.

The horizontal accuracy of the digital orthoimagery will be checked, measured, and evaluated against photo identifiable checkpoints. As defined by ASPRS, the primary horizontal accuracy standard for digital orthoimagery specify horizontal accuracy classes in terms of $RMSE_H$—the combined linear error along a horizontal plane in the radial direction. For the state of Indiana, the digital orthoimagery will be produced to meet the ASPRS Positional Accuracy Standards for 7.5-cm horizontal accuracy class, meaning the $RMSE_H$ for the resulting data set must be less than or equal to 7.5 cm. And for the case in areas of digital orthoimagery mosaics, there will be an additional criterion for the allowable mismatch at seamlines of $\leq 2^* RMSE_{H,}$ $\leq$ 15.0 cm. The horizontal accuracy of the digital orthoimagery will be reported accordingly in the project reports and metadata.

The lidar data collected for the Indiana statewide program will be assessed and reported in accordance with the ASPRS "Positional Accuracy Standards for Digital Geospatial Data, EDITION 2, VERSION 1.0". The standards will specify vertical accuracy be provided as $RMSE_{V,}$ with the inclusion of the checkpoint accuracy when computing the accuracy of the lidar data, in both vegetated and non-vegetated terrain.

The vertical accuracy is evaluated by comparing the elevations of the surface produced by the lidar data set with elevations from the independent checkpoints of higher accuracy. This will be performed by comparing checkpoint elevations with lidar data interpolated elevations set at the same X, Y coordinates. For example, the reporting for vertical positional accuracy will state, "This data set was evaluated to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data, Edition 2, v2 (2024) for a __(cm) $RMSE_V$ Vertical Accuracy Class. The Non-Vegetated Vertical Accuracy (NVA) was found to be $RMSE_V$ = __(cm) while the Vegetated Vertical Accuracy (VVA) was found to be $RMSE_V$ = __(cm)." The reporting of the horizontal positional accuracy will state, "This data set was evaluated to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data, Edition 2, v2 (2024) for a __(cm) $RMSE_H$ Horizontal Positional Accuracy Class. The tested horizontal positional accuracy was found to be $RMSE_H$ = __(cm)." The reporting the three-dimensional positional accuracy will state, "This data set was evaluated to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data, Edition 2, v2 (2024) for a ___ (cm) $RMSE_{3D}$ Three-Dimensional Positional Accuracy Class. The tested three-dimensional accuracy was found to be $RMSE_{3D}$ = __ (cm) within the NVA evaluated area and $RMSE_{3D}$ = __ (cm) within the VVA tested area." Interswath and intraswath accuracies will be assessed in accordance with the current USGS lidar base specification for QL1. Interswath $RMSD_Z$ will be 8 cm or less and intraswath $RMSD_Z$ will be 6 cm or less. Both will be reported in the metadata accordingly.

3.1.10 Describe your process to constrain building lean within the orthoimagery and to account for excessive building lean, particularly in areas with concentrations of structures over 5 stories.

Woolpert's acquisition and processing of aerial imagery is designed to mitigate the effects of tall buildings and dark shadowing. From past experiences, we appreciate the special nature of the central business district (CBD) areas of Indianapolis, Fort Wayne, Evansville, etc. The CBD areas require (based on desired pixel resolution) a unique and professional solution to mitigate the radial displacement of tall buildings. If deemed necessary, the CBD areas will be flown with additional flights at 60% (or greater) side lap, which provides additional imagery coverage for Woolpert's imagery specialists to reduce building lean, shadows, and other types of occlusions. In addition, our proposed flight plan will acquire imagery at a higher altitude, equating to a more top-down view of ground features resulting in less building lean.

3.1.11 Describe your experience and solution to provide an Open Geospatial Consortium (OGC) Web Map Service (WMS) to allow Internet viewing of the orthoimagery in production for visual QC.

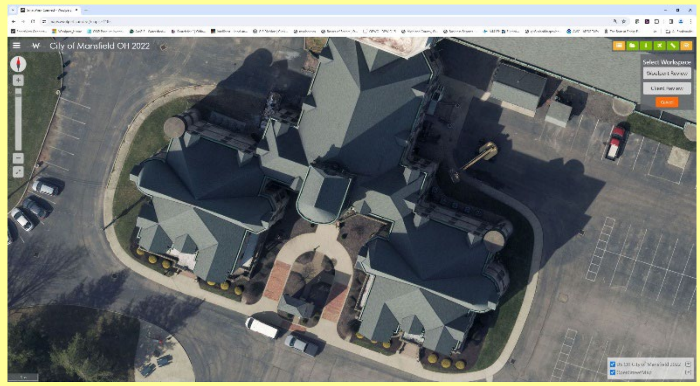
Open Source Software (OSS). Woolpert has an extraordinary reputation for delivering massive amounts of geospatial data via OGC compliant WMS and WMTS services. We currently have more than 25 TB of imagery being served to hundreds of individual clients, client agencies, and the general public daily. These datasets include basic orthophotography at 2-inch to 12-inch resolution, rasterized lidar datasets, and rasterized vector datasets.

Our WMS and WMTS service expertise is not limited to the implementation within Woolpert. In fact, we have set many such servers up at client locations and even in the public cloud (Amazon/Microsoft/Google). Beyond our experience with deploying these web mapping servers, Woolpert is very well versed in all the major WMS servers our clients use including ArcGIS Server, MapServer, CartoDB, and other lesser used, open-source solutions. We have created our own OGC compliant WMS and WMTS service that is both highly scalable AND highly dependable while also being able to work with cached imagery to maximize serving performance and deliver the expected end user experience.

3.1.12 Describe how you will provide a web-based viewer to the State for visual quality control (QC) review (including tracking callouts and corrections) of the imagery before the final data delivery. Include details of your experience with web-based QC solutions.

Woolpert developed its SVC (http://maps.woolpert.com/) web-based redline tool to host very large imagery datasets, facilitating efficient response from clients for rapid delivery of quality digital products. Our SVC website can host terabytes of raster data. The challenge with such large datasets is in the data processing, delivery, and viewing in an efficient manner. With commodity hardware, open-source software, and open standard web services, our developers quickly process and deliver such datasets over the web for the purposes of quality control, visualization, and analysis.

By leveraging high-performance, cluster computing techniques and the Geospatial Data Abstraction Library (GDAL), we generate web-optimized image caches in a matter of minutes. Generating these caches using commercial off-the-shelf software would take exponentially more time, even days depending on the size of the dataset. These caches, exposed via Open Geospatial Consortium (OGC) compliant web services, can then be easily ingested by any number of desktop and web-based products.



SVC's browser-based viewer displays imagery and DEM data along with relevant reference datasets (i.e., client GIS datasets including parcel mapping, building outlines, etc.) and provides tools for redline markups and workflow management. This workflow platform serves as a central database for internal and client feedback which can then be brought into other tools for resolution.

Within 10 days of imagery collection, raw imagery will be published to SVC. Upon Woolpert completing orthoimagery production and associated data QA/QC, our staff will publish the deliverables and alert all relevant parties that imagery is available.

A report will then be created, and revised data will be posted once the issue has been fixed. After all issues and concerns have been addressed, final data preparation will include a geodatabase of issues, along with all the required project deliverables. To date, Woolpert has successfully used SVC for client QA and has reviewed more than 200,000 square miles of imagery and more than 50,000 square miles of lidar.

3.1.13 We anticipate that the photogrammetry staff from the Indiana Department of Transportation will perform a quality review. How will you use their capability to ensure a superior product for Indiana?

Woolpert has extensive experience working with the Indiana Department of Transportation (INDOT) management and technical staff. Our approach to maximizing INDOT capabilities staff would begin with a detailed communication plan and measurable milestones. The communication plan would clearly identify technical points of contact within Woolpert and INDOT so technical questions or comments can be addressed quickly between Woolpert and INDOT.

We also understand INDOT management and resources have other commitments, and their time is valuable. Woolpert will provide measurable milestones for deliverables so INDOT management can plan resources accordingly. Additionally, there is a tremendous time savings in using the SVC QC tool. By eliminating the need to ship and load/unload hard drives, the INDOT staff can be notified by email that delivery is ready for QC. Within minutes, INDOT staff can be logged in and making calls on the SVC tool minimizing down time and maximizing effort. For INDOT staff or management unfamiliar with the SVC tool, training sessions can be set-up before deliveries begin.

In early spring of each year, Woolpert staff will meet with Indiana staff to review SVC and discuss editing guidelines. After SVC edit calls are reviewed and final orthoimagery created, Woolpert will prepare the final data and upload to the cloud for delivery. Data will be delivered on a county-by-county basis as soon as a delivery area is completed. All data will be processed and delivered prior to November 30 of each year.

3.1.14 Describe how your processes are designed to eliminate errors. Detail the steps taken for review of products. Describe how rejected products will be handled, including re-flights, tile errors, mosaic errors, and radiometry errors.

It is Woolpert's proactive approach to projects allows us to deliver geospatial data of the highest quality to our clients. Our goal for every project and every client is first time right delivery. Woolpert is ISO 9001:2015 certified by the ANSI-ASQ National Accreditation Board (03/2000) for the acquisition, processing, and utilization of geospatial data through photogrammetric/remote sensing techniques (certificate #11-R8033). Woolpert will maintain this certification throughout the duration of this project. Our certification demonstrates we have coherent, documented QA/QC procedures in place to successfully complete all services in the required time.

During the acquisition season, our staff runs the raw imagery data through an initial QC process within 48 hours of acquisition to ensure all program guidelines have been met. This allows any necessary re-flights to be accomplished as soon as possible after the date of the original acquisition. Ryan will be in constant communication with the State and/or local officials regarding acquisition conditions. In unusual circumstances such as flooding or significant snow events, Woolpert reviews these circumstances with the client to determine if the acquisition should take place. If a problem is found further into the production process – post acquisition season – Woolpert will immediately contact the State regarding the issue and develop a mutually agreed upon resolution, up to and including re-flights the following season.

Through our experience on prior statewide projects, we have learned to expect an average of 10-percent reflights per season because of weather or ground conditions. As part of our project plan, Woolpert will allocate resources and a schedule based on reflights of 10-percent of the total flight lines, and schedule acquisition crews to re-acquire these particular areas prior to leaving the project area. Additional resources are available if a flying season becomes particularly challenging due to weather or ground conditions.

Woolpert uses a semi-automated approach to image mosaicking and tonal balancing using OrthoVista software. All the images will be merged to help eliminate mismatches between tiles in brightness and tonal quality. Tiles will then be clipped from the mosaicked image and all adjacent tiles will edge match with surrounding tiles. Tiles are then run through a visual QA/QC to ensure no automated errors are introduced in this step. As part of the final deliverables, Woolpert will deliver a shapefile containing the mosaic seam line information. The resulting digital orthophotos will have accurate X, Y ground coordinates, and RGB and near infrared band values from 0 to 255. The final imagery is checked against existing control features to verify horizontal accuracy meets ASPRS standards for the appropriate mapping scale.

Prior to delivery, Woolpert's quality control group runs several proprietary QC tools that automatically check file naming, formatting, and header information. These QC tools can be customized to recognize specific information or formatting to identify possible errors. These errors are then manually reviewed by the QC staff and corrected as needed for final delivery.

3.1.15 Explain your ability to re-visit flights in particular areas in the event the imagery is rejected during the QC process.

During the acquisition season, our staff runs the raw imagery data through an initial QC process within 48 hours of acquisition to ensure all program guidelines have been met. This allows any necessary re-flights to be accomplished as soon as possible after the date of the original acquisition. The Project Manager, Ryan Bowe, and Production Manager, Matt Worthy, will be in constant communication with the State and/or local officials regarding acquisition conditions. In unusual circumstances such as flooding or significant snow events, Woolpert reviews these circumstances with the client to determine if the acquisition should take place. If a problem is found further into the production process – post acquisition season – Woolpert will immediately contact the State regarding the issue and develop a mutually agreed upon resolution, up to and including re-flights the following season.

Through our experience on prior statewide projects, we have learned to expect an average of 10-percent reflights per season because of weather or ground conditions. As part of our project plan, Woolpert will allocate resources and a schedule based on reflights of 10-percent of the total flight lines, and schedule acquisition crews to re-acquire these particular areas prior to leaving the project area. Additional resources are available if a flying season becomes particularly challenging due to weather or ground conditions.

3.1.16 Describe the types of radiometric adjustment incorporated into your production processing and quality control workflow.

The imagery will be radiometrically adjusted to include color balancing, overall tone adjustment, and brightness and contrast enhancements of the imagery over the entire project. Dark and light areas shall be evened out. Woolpert will forward a representative sample of urban, rural, agricultural, forest and wetland areas to the State for review and approval of the radiometric settings prior to orthoimagery production commencement. The agreed upon settings will be applied to all subsequent imagery deliverables.

As part of Woolpert's orthoimagery QA/QC process, each digital orthoimage will be checked and corrected to ensure a proper and consistent tone, as well as density, contrast, and brightness qualities. Each image will be checked on the screen at the intended output scale for image defects or other blemishes.

3.1.17 Include a description of processes and software used for ortho rectification, mosaicking, and tiling. Address how the processes will eliminate or minimize radial displacement, building lean, and spectral reflectance from water surfaces.

Our process will include the use Leica's XPRO processing software for the generation of the digital ortho-rectified imagery. Our internal production processing requirements for data handling and processing are significant. With daily throughput of terabytes of digital imagery data, our main in-house processing system in Dayton, Ohio was customized to meet the needs for processing large volumes of data rapidly and efficiently. Our internal production demands have prepared us for managing complex and varied computing environments.

The processing software utilizes the imagery, the DTM, and the exterior orientation parameters generated from the aerial triangulation to produce high quality digital ortho-rectified Image for each flight line. The ortho-rectified image will be produced from the most central part of the image. Once the ortho-rectified images are produced, a thorough review will be conducted to flag any anomalies in the products. If such anomalies are observed, technical staff will analyze the problem and devise the right solution. If such anomalies are due to the quality of the aerial triangulation solution, the aerial triangulation for the block where this imagery is located will be reviewed and corrective action will be taken if necessary. If the anomalies are due to problems in the DTM similar approach will be followed and corrective action will be taken until all ortho-rectified images of the flight lines of the block are free from any geometrical defect. The resulting digital orthoimagery will have a 6-inch pixel resolution, with accurate X, Y ground coordinates, and RGB scale values from 0 to 255.

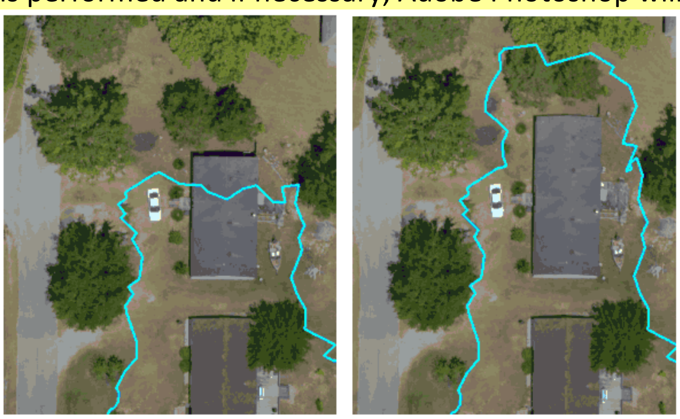
The ortho-rectified images will then be run through a process of generating a seamless mosaic. OrthoVista (used for mosaicking the aerial imagery acquired with the DMC) software provides the users with many options to minimize the effects of color and tones differences between flight lines and manipulate seam lines placement if necessary. Once the mosaic is finalized, ortho-rectified tiles are produced in accordance with the layout as specified in the project plan. Tiles will be clipped from the mosaicked image so all adjacent tiles will edge match with surrounding tiles. Tiles are then run through a visual QA/QC to ensure no automated errors are introduced in this step.

Our image specialists will take special care around bridges, overpasses, water towers, and radio towers to correct excessive distortion. Bridges and overpasses will not appear to be warped or skewed. Visible seamlines are acceptable over large bodies of water. Building roof tops, water towers, and radio towers shall not be clipped at seamlines or between individual image files.

Mismatches along mosaic seam lines greater than 3-pixel will be corrected:

- 3-inch – mismatch greater than 9-inches.
- 6-inch – mismatch greater than 18-inches.

As much as possible, we will produce digital ortho-rectified imagery with consistent tone and contrast throughout the production blocks, as well as within single tile. Brightness trends between images due to seasonal differences in vegetation or due to incident sun angle will be processed to minimize the visual differences by careful placement of cutlines and blending of image overlaps. Woolpert has developed proprietary software for color balancing and image dodging. At the very end of mosaic production, final review is performed and if necessary, Adobe Photoshop will be used for fine adjustment of enhancement.



Invalid Seam line   Corrected Seam line

As part of the image processing procedure, Woolpert will provide a pilot area image dataset for the state to review. The dataset will have the tonal and color balance and will be used as a guideline for the remainder of the project.

Woolpert has the state of Indiana’s original image tile grid that can be modified, as needed, when county or other agencies buy up to a higher resolution. The tiles will be seamless and match adjacent tiles in tone and color balance as ground and sky condition allow. The following tile sizes will be used:

- 6-inch. 2,500’ x 2,500’.

- 3-inch. 1,250’ x 1,250’.

The final mosaicked dataset is then cut into appropriate tile layouts based on the final pixel resolution. Tiles are then manually reviewed and corrected using Adobe Photoshop software. Final tiles are then loaded to SVC for client review.

Overall, digital imagery systems eliminate blemishes, scratches, and dust once prevalent on film products. The imagery remains digital throughout the process from camera to final product.

3.1.18 Describe your process to produce and quality check derived imagery products.

Woolpert’s approach to the production and quality control of ECW or MrSID imagery starts with the GeoTIFF imagery. To ensure best possible error free ECW or MrSID products, Woolpert uses individual GeoTIFF imagery resulting from Woolpert’s extensive ISO quality control processing. In addition, the GeoTIFF imagery is posted to SVC where any client review comments can be addressed before conversion to ECW or MrSID format.

To create ECW imagery, final GeoTIFF imagery is batch processed in ERDAS ER Mapper software to create individually compressed Version 2, ECW files. GeoTIFF information then is applied to the ECW file to create the reference information for the image where a set of .ecw/.aux/.xml projection information is created for each ECW file for use by the client. Technicians use custom Arc tools to compare ECW georeferenced information, file counts, and against client-approved tile layouts. A final check is run comparing the original final datasets on our network to the final datasets on the hard drives to ensure they match, and the client is getting the correct files.

Woolpert uses LizardTech’s GeoExpress software to compress the tiled color digital orthophotos and exported to MrSID Generation 4 (8-bit) format for image viewing and sharing purposes. As part of Woolpert’s QC process, the extents of the MrSID files will be verified to ensure complete AOI coverage and delivered in the appropriate zone and unit of measurement. Woolpert recommends ECW or MrSID files be compressed at a 20:1 ratio, with no "No-Data" areas, delivered in 2,500 x 2,500-foot grid tiles in the appropriate Indiana State Plane East or West zone.

3.1.19 Describe the process and tools used to create the DEM bare-earth digital elevation model (DEM) generated from the acquired lidar suitable for creating the new orthoimagery in a timely manner.

Woolpert will employ our AI/ML technology to process the lidar DEM for use during the imagery rectification process. As the high-density lidar at 25 ppsm is well suited for the utilization of AI/ML. This process will allow us to turnaround processing of the DEM quickly, ensuring the most up-to-date DEM is utilized, thus providing the highest accuracy.

To expedite the orthoimagery production, Woolpert will utilize automated classification methods, to produce a DEM from the acquired lidar data suitable to support the rectification of the orthoimagery. Woolpert provides access to a comprehensive Geospatial Data Platform that includes AI services for automating the creation of information products. This platform has been developed with the latest cloud-computing and AI technologies to ensure fast access to surface models.

- The lidar data starts as collected data converted into geo-located point clouds (i.e., georeferenced data) where it is loaded into a cloud storage environment. Once in the cloud, the georeferenced data is tiled, indexed, and prepared for interrogation.
- From there, a collection of automated surface generation and planimetric feature extraction services

are available. Each individual surface model (i.e., bare earth, vegetation classification, elevation derived hydrography, etc.) or asset features (i.e., buildings, roads, powerlines, wires, etc.) will be run as a separate, AI-powered extraction service.

- Extraction services are built through machine learning, so assets are trained from previous projects. AI for surface models is trained to identify anomalies and detect common data defects.
- Once an extraction service is complete, the completed surface models will be put through a quality control process. Each result is assigned a confidence where high confidence is likely to be correct and low confidence may be mislabeled. Low confidence assets will be reviewed by a technician for verification.
- Verified results are then placed into a distribution server where it can be accessed to expedite the orthoimagery rectification.

After the ortho DEM has been processed, it will undergo additional processing utilizing Terrasolid products. The DEMs are produced with the following specifications:

- The DEM will be created from the bare earth surface model created during filter, classification, and editing of the raw point cloud data.
- DEM elevations will be in meters to two decimal values.
- DEM post positions will be clipped to the appropriate tile formats. The DEM grid will be at a resolution of no greater than 0.5 meters.
- DEMs will be hydroflattened.
- DEM tiles will show no edge artifacts or mismatch.
- Delivery format will be 32-bit floating point Cloud-Optimized GeoTIFF raster.
- GeoTIFF keys and tags will be generated using GDAL.
- Georeference information as appropriate for the file format to include both horizontal and vertical systems. As current GeoTIFF standards do not allow for the inclusion of the geoid model used to convert from ellipsoid to orthometric heights, the geoid name will be listed in the final lidar mapping reports and be appended in the WKT of the corresponding point cloud files.

3.2 Elevation Data Captured Using Lidar

3.2.1 Explain your ability to complete the specifications outlined in Section 7.1.2 of Attachment N.

Woolpert is very familiar with the various lidar industry standards including the ASPRS Positional Accuracy Standards for Digital Geospatial Data, National Standard for Spatial Data Accuracy (NSSDA), and the current National Geospatial Program Lidar Base Specification 2024, Revision A” (LBS 2024, Revision A). To ensure consistent methodologies are used on this contract, our team will follow project planning and execution and QA/QC procedures developed through Woolpert’s certified ISO program in conjunction with the current LBS guidelines provided by the USGS.

Our background gives us several advantages, including: the ability to retain staff and supplement as needed for surges in services and last-minute requests; effective subcontractor management methods that achieve compliance with Woolpert’s ISO 9001:2015 processes; the ability to communicate proactively with client Project Managers to co-manage large-scale projects, as well as to better understand and meet client needs; and continuously refined quality performance standards and management procedures based on ISO standards and PMI best practices.

- **Aerial Acquisition.** Woolpert operates eight high-performance aircraft in North America—four Cessna 404s, two Reims F406s and two Beechcraft Super King Air 300. These aircraft, configured with dual ports for simultaneous data collections, are outfitted with computer control navigation systems (CCNS) and multiple aerial data sensor systems – all equipped with GPS/GNSS/IMU technology. All acquired data is positioned using airborne Kinematic GPS.

Woolpert Zeus Lidar Sensor

- **Lidar Sensors**. Woolpert is deeply committed to being an industry leader in lidar by procuring and designing the latest sensors and innovative systems. Our dedication to achieving our projects' specified density and accuracy requirements (in this case delivering USGS 3DEP QL1 high density lidar with an average point density of 25ppsm) is reflected in our continuous investment in state-of-the-art lidar technology. We prioritize integrating advanced lidar and imagery systems into our workflows, ensuring the highest precision in data collection and the ability to surpass demanding specifications for density and accuracy. Moreover, when faced with a technology gap, Woolpert goes beyond conventional off the shelf solutions. We have undertaken rigorous research, design, and engineering efforts to craft solutions, address specific challenges, and provide our clients with tailor-made, high-performance lidar capabilities.

High Point Density Lidar - Please note the identification of power distribution lines.

- **Surveying.** Woolpert recognizes the necessity of establishing GCPs, independent check points, airborne GPS base stations, land cover classification points and other survey data to support the airborne data acquisition. Woolpert provides an array of surveying services to support all stages of a project, from initial planning through design and construction. Specific to this effort, ground control in support of aerial acquisition.
- **Lidar Processing.** Woolpert utilizes a combination of commercial and proprietary software to process, calibrate, and classify lidar data to meet USGS lidar specifications. Following processing, vertical accuracy testing is performed on the bare earth surface using independent lidar check points to determine the accuracy of the lidar point cloud. Utilizing the bare earth data and the lidar intensity imagery, hydrologic flattening of streams and water bodies is processed to create a hydrologically flattened DEM.
- **Data Deliverables.** Our metadata/data delivery specialists are well-versed in providing quality-controlled data on the proper delivery media, in the appropriate tile layout, naming convention and projection as defined by the client.

3.2.2 In the past five years, have any final deliverables for statewide lidar projects been rejected by the client, and if so, how did you resolve these issues?

In the past five years, Woolpert has not received any formal rejection of final deliverables for statewide lidar projects. As with the orthoimagery response to item 3.1.2, we fully understand when conditions are appropriate to perform aerial acquisition, reducing the likelihood of non-conformant data deliverables significantly. Likewise, Woolpert strongly encourages the use of pilot deliverables to guarantee the processes and procedures being applied to the surveyed datasets conform to the expectations of the State and its partners.

It is common for clients such as the USGS to request additional review of initial lidar deliverables. Upon receipt of such requests, Woolpert validates the provided information, assesses the scope of the request, and then applies the most effective corrective action. Simultaneously, Woolpert's Quality Management System (QMS) protocols are triggered to record the cause and corrective action of each item, while ensuring each affected team has implemented measure to mitigate or eliminate the issue for future deliverables. When a request is made for additional review of the initial lidar deliverables, we usually resolve within one correction cycle; to reduce the time between when the data is submitted to the USGS for their internal review and ultimate acceptance, we will provide Indiana with a preliminary dataset while the USGS is preparing the data for the public domain. We have performed this delivery of preliminary data for several clients for use while the formal review/acceptance process is underway.

3.2.3 Describe your approach for using existing control or establishing new ground control of sufficient density and accuracy to meet the requirements of the lidar deliverable. Describe how you intend to perform required independent accuracy testing.

Woolpert will incorporate the existing 2016-2020 statewide lidar control, along with other existing control into our project workflow. If needed, new control points will be established. For additional control points, the Woolpert team will initially look to existing 2021-2023 orthoimagery control which includes adequate x, y, and z information. If new control points are necessary, Woolpert chooses to use Photo Identifiable (PID) points as often as possible. PID points are more environmentally friendly and prevent unnecessary public intrusion and interference in the community. PID points will be picked on clear, well defined locations photo identifiable from the appropriate scale. The PID points will be semi-permanent locations, such as the intersection where the edge of a concrete driveway meets a concrete sidewalk. The new PID GCPs will be consistent with second order horizontal and third order vertical.

Our ground control survey steps include:

- Overlaying existing PID point locations onto new flight layouts to review proper distribution for required products.
- Overlaying existing PID points on newly acquired imagery to determine whether PID's are valid or removed/destroyed.
- Locating new/alternative points if existing PID points are no longer viable or destroyed.
- Producing control diagram with existing and new points.
- Performing survey field mission to perform GPS observations.
- Performing computations and generate coordinates.
- Producing survey report.

Woolpert will provide a survey report containing all the pertinent information required, such as control diagrams, point descriptions and diagrams, log sheets, etc.

We propose to reference the American Society for Photogrammetry and Remote Sensing (ASPRS) "Positional Accuracy Standards for Digital Geospatial Data, EDITION 2, VERSION 1.0" as the basis of the accuracy standards for the State's program. Our approach to independent accuracy testing aligns with current ASPRS standards, ensuring the highest industry benchmarks for horizontal and vertical accuracy. For horizontal accuracy, we conduct meticulous assessments using GCPs and reference data, adhering to the ASPRS/NSSDA standards and with a minimum of 2 two checkpoints per county. In buy-up areas, additional checkpoints are strategically placed to enhance scrutiny based on terrain characteristics. Similarly, for lidar vertical accuracy, our testing protocol adheres rigorously to the ASPRS standards, incorporating GCPs for calibration and independently surveyed checkpoints for the accuracy analysis. This comprehensive evaluation, meeting or exceeding specified standards, is detailed in a transparent accuracy final project report, providing clients with a clear understanding of the reliability and precision of our orthoimagery and lidar datasets.

3.2.4 Describe how horizontal and vertical accuracy will be established and used based on proposed sensors, collection techniques and processing.

Our team's survey crews will collect the photo control points using Rapid Static- and GPS-based RTK survey techniques. For an RTK survey, ground crews use Trimble Navigation's 5000 series dual frequency roving unit to receive radio relayed, corrected positional coordinates for all ground points from a Trimble GPS base unit set up over a survey control monument. These control points are tied and adjusted to published NGS control stations to ensure quality X, Y, and Z values are established.

For new control and check points, the Woolpert team will use Photo Identifiable (PID) points as often as possible. PID points are more environmentally friendly and prevent unnecessary public intrusion and interference in the community. PID points will be picked on clear, well defined locations photo identifiable from the appropriate scale. The PID points will be semi-permanent locations, such as an "X" etched in concrete, PK Nail, or 18" rebar with a cap at the intersection where a concrete driveway meets a concrete sidewalk or end of a paint stripe. The new PID GCPs will be consistent with second order horizontal and third order vertical.

Woolpert will perform initial post processing of the aerial mission by using airborne GPS and implement these results into the aerial triangulation process. GCPs are measured during the aerial triangulation process, and additional check points are withheld to be used later to verify the accuracy of the project.

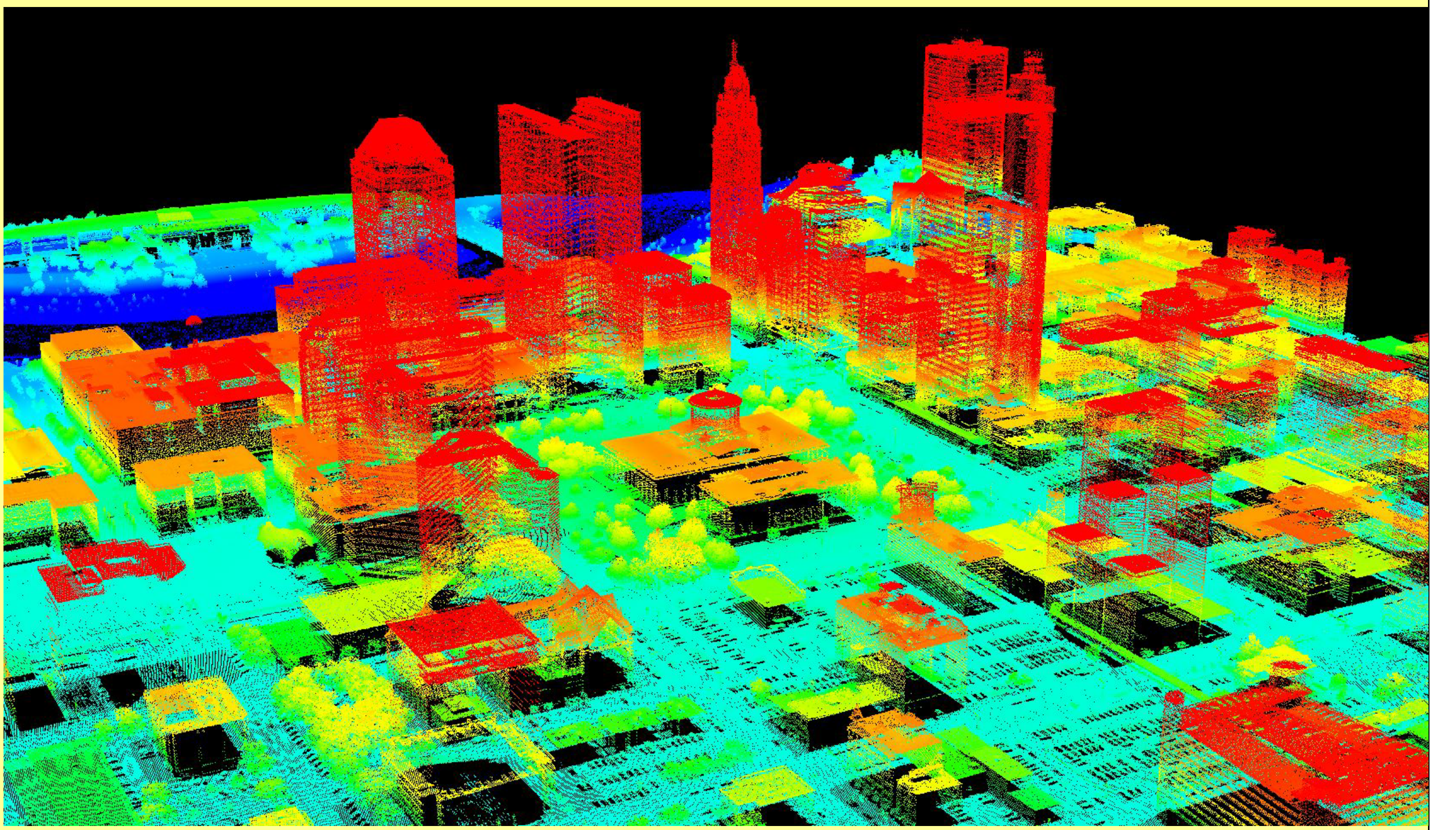
Woolpert will provide a Survey Report containing all the pertinent information required such as – control diagrams, point descriptions and diagrams, log sheets, etc.

3.2.5 Describe the process and tools used to align separate swaths and classify the lidar points including differentiating between various classifications listed in Section 7.1.2 of Attachment N.

The lidar data processing team employs specialized software tools such as TerraScan and/or LASTools. These tools facilitate the identification of tie points between overlapping swaths, allowing for the precise adjustment of the lidar point cloud data. Additionally, the integration of Global Navigation Satellite System (GNSS) data enhances the accuracy of the alignment process, contributing to the overall quality of the DEM. The methodology for swath alignment involves meticulous attention to detail. Tie points are strategically identified in areas where swaths overlap, and adjustments are made to minimize any discrepancies in elevation or position. This rigorous adjustment process ensures the lidar point clouds from different swaths seamlessly blend into a cohesive dataset. The goal is to eliminate any discontinuities or visual artifacts that may arise from variations in data acquisition, flight conditions, or sensor characteristics.

3.2.6 Describe your process to adequately collect lidar in urban areas to ensure adequate ground coverage.

Leveraging advanced airborne lidar sensors with high pulse repetition rates and multiple returns per each discrete pulse, our lidar data collection methodology ensures an exceptionally high-density point cloud capturing intricate urban details. Adaptive flight planning addresses the challenges of complex landscapes, while sophisticated point classification algorithms distinguish ground surfaces from structures, vegetation, and other features. By surpassing specified density thresholds, our approach guarantees precise and comprehensive elevation information beneath urban canopy features.



The image above depicts aerial lidar saturation covering a densely urbanized area. The flight plan and sensors used allow for no areas of occlusion.

3.2.7 Describe the processes and software used for hydro-flattening, including how bodies of water will be determined.

Our hydro-flattening process is meticulously designed to ensure accurate representation and uniformity of water bodies in the generated lidar-derived Digital Elevation Models (DEMs). The methodology involves the application of advanced GIS software, including Esri's ArcGIS, to identify and delineate bodies of water based on lidar point cloud data. Using elevation thresholds, point density analysis, and intensity values, the software classifies water features, distinguishing them from surrounding terrain. Hydro-flattening algorithms are then applied to ensure a consistent elevation surface for water bodies larger than 2 acres, as well as streams and rivers wider than 100 feet. The process includes the removal of undulations caused by wave action and other irregularities, providing a smooth representation of water surfaces. The software-driven hydro-flattening is complemented by manual quality checks to address any anomalies and ensure the accuracy and completeness of the water body representations in the final DEMs.

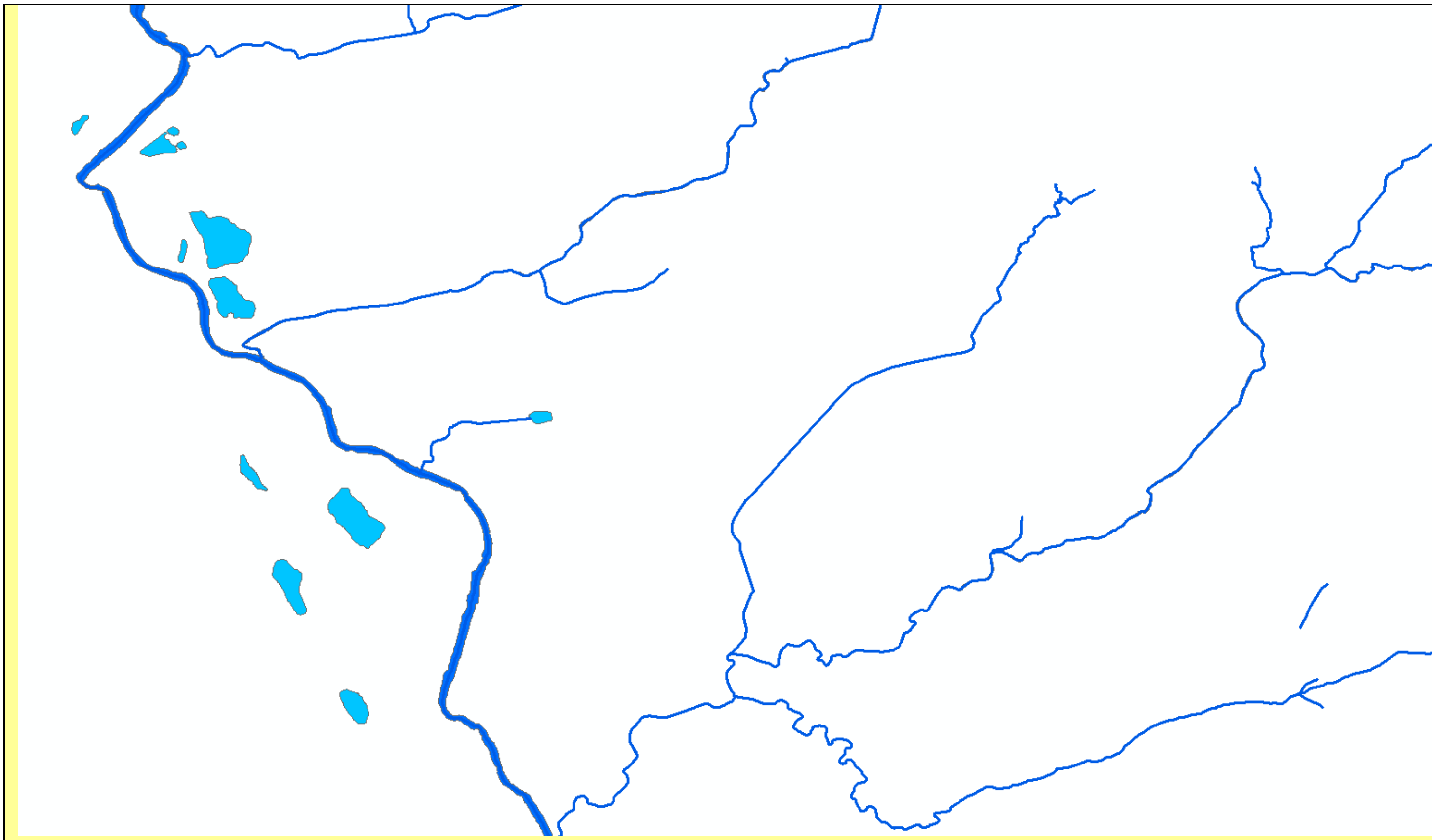


Image above depicts an example of hydro-flattening

3.2.8 Describe how you will provide a web-based viewer to the State for visual quality control (QC) review (including tracking callouts and corrections) of the DEM product detailed in Section 7.1.2 of Attachment N prior to final data delivery. Include details of your experience with web-based QC solutions.

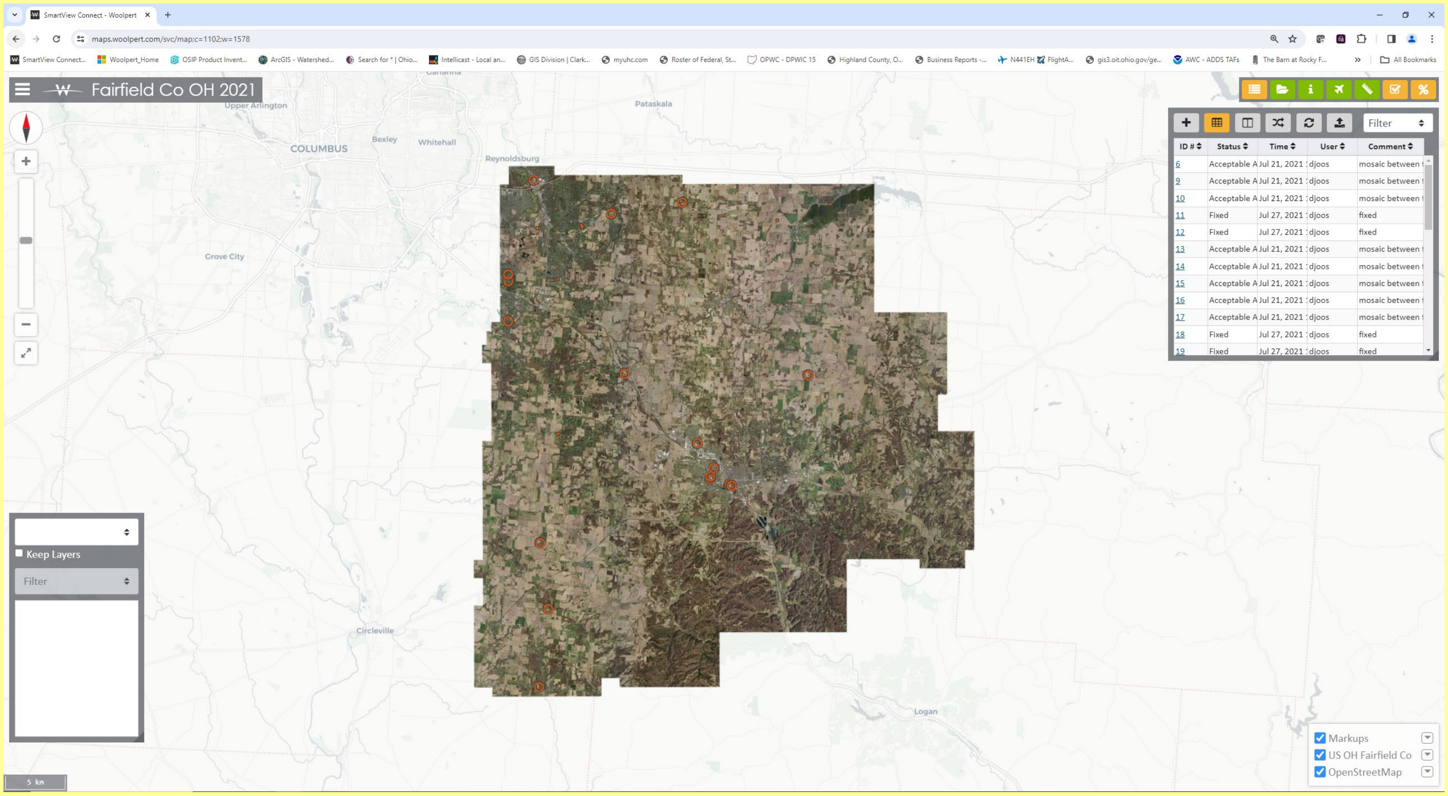
Woolpert developed the SVC (http://maps.woolpert.com/) web-based redline tool to host very large imagery and vector datasets, to facilitate efficient response from clients for rapid delivery of quality digital products. Our SVC website can host terabytes of geospatial data. The challenge with such large datasets is in the processing, delivery and viewing of this data in an efficient manner. With commodity hardware, open-source software, and open-standard web services; the Woolpert developers were able to quickly process and deliver such datasets over the web for the purposes of quality control, visualization, and analysis.

By leveraging high-performance, cluster computing techniques and the Geospatial Data Abstraction Library (GDAL); we generate web-optimized image caches in a matter of minutes. Generating these caches using commercial off-the-shelf software would take exponentially more time, in the order of days, depending on the size of the dataset. These caches, exposed via Open Geospatial Consortium (OGC)-compliant web services, can then be easily ingested by any number of desktop and web-based products.

SVC, our browser-based viewer, displays imagery and DEM data along with relevant reference datasets and provides tools for redline markups and workflow management. This workflow platform serves as a central database for internal and client feedback which can then be brought into other tools for resolution.

Upon Woolpert completing lidar data processing and associated QA/QC of the data, our staff will publish the lidar-derived hydro-flattened DEM rendered as a shaded relief to the SVC platform. If the State chooses to acquire advanced classification of vegetation and buildings, Woolpert will also publish a DSM to the SVC platform in accordance with the SOW.

The State and/or its stakeholders will then log onto the site and immediately access the deliverables via a browser. There will be no need to install proprietary software. The main advantage of using this system, other than the time and cost savings, is the SVC issue tracking tools. In the event the State or a partner encounters an error in the data while browsing the site, they will be able to markup the error on the screen using tools available in SVC. Because each member of the State team will be granted a username to access the site, each issue created will be stored and tracked within the system and the Woolpert team will immediately respond to that issue.



The image above provides an example of quality inquiries made by a client and the resolution taken by Woolpert.

A report will then be created, and revised data will be posted once the issue has been fixed. After all issues and concerns have been addressed, final data preparation will include a geodatabase of issues, along with all the required project deliverables.

3.2.9 We anticipate that the USGS will perform the quality assurance of the data to the Lidar Base Specification. Describe how you will work with the USGS for this process.

To facilitate an effective and collaborative quality assurance process, Woolpert promotes a comprehensive engagement with the USGS. Our approach involves transparent communication and regular updates at key milestones throughout the lidar data production process. The Project Management team will establish a dedicated point of contact to serve as a liaison between our team and the USGS, ensuring a seamless exchange of information.

Regular feedback sessions and open lines of communication will be established to address any queries promptly and implement adjustments, if necessary. Additionally, we propose periodic joint reviews where representatives from our team will work closely with USGS personnel to assess the data against the Lidar Base Specification. This collaborative effort aims to streamline the quality assurance process, allowing for real-time adjustments and ensuring the final deliverables meet or exceed the stringent standards set by the USGS.

3.2.10 We anticipate that the staff from the State of Indiana will perform a quality review. How will you use their capability to ensure a superior product for Indiana?

Woolpert has extensive experience working with the INDOT management and technical staff. Our approach to maximizing the capabilities of INDOT staff would begin with a detailed communication plan and measurable milestones. The communication plan would clearly identify technical points of contact within Woolpert and INDOT so technical questions or comments can quickly be addressed between Woolpert and INDOT.

We also understand INDOT management and resources have other commitments, and their time is valuable. Woolpert will provide measurable milestones for deliverables so INDOT management can plan resources accordingly. Additionally, there is a tremendous time savings in using the SVC QC tool. By eliminating the need to ship and load/unload hard drives, the INDOT staff can be notified by email that delivery is ready for QC. Within minutes INDOT staff can be logged in and making calls on the SVC tool minimizing down time and maximizing effort. For INDOT staff or management unfamiliar with the SVC tool, training sessions can be set-up before deliveries begin.

In early spring of each year, Woolpert staff will meet with State staff to review SVC and discuss editing guidelines. After SVC edit calls are reviewed and final orthoimagery created, Woolpert will prepare the final data and upload to the cloud for delivery. Data will be delivered on a county-by-county basis as soon as a delivery area is completed. All data will be processed and delivered prior to November 30 of each year.

3.2.11 Describe how your processes are designed to eliminate errors. Detail the steps taken for review of products. Describe how rejected products will be handled, including re-flights, and lidar swath.

Our processes are meticulously designed to eliminate errors through a multi-faceted approach. During the lidar data collection phase, we employ state-of-the-art sensor calibration, ensuring accurate and precise data capture. Additionally, stringent quality control checks are integrated into our workflow, ranging from hydro reclassification macros, and drawing reviews to vertical variance checks on water bodies, bridges, and breaklines.

The review of products is a comprehensive stage where multiple QC checks are conducted, including hydro reclassification, geometry checks, DEM reviews, and intensity imagery product verification. The lidar data undergoes thorough scrutiny, addressing issues like null values, elevation discrepancies, and ensuring compliance with USGS Lidar Base Specification standards.

In the event of rejected products, our procedures are well-defined. Rejected lidar data may necessitate re-flights, contingent on the nature and extent of the discrepancies. The lidar swath is carefully examined, and corrective actions are implemented to rectify errors. Our commitment to delivering high-quality products is reflected in our proactive approach to error resolution, ensuring final deliverables align with the highest industry standards.

3.2.12 Explain your ability to re-visit flights in particular areas in the event the lidar is rejected during the QC process.

During the acquisition season, our staff runs the raw lidar data through an initial QC process within 48 hours of acquisition to ensure all program guidelines have been met. This allows any necessary re-flights to be accomplished as soon as possible after the date of the original acquisition. The Project Manager, Ryan Bowe, and Production Manager, Matt Worthy, are in constant communication with the State and/or local officials regarding acquisition conditions. In unusual circumstances such as flooding or significant snow events, Woolpert reviews these circumstances with the client to determine if the acquisition should take place. If a problem is found further into the production process – post acquisition season – Woolpert will immediately contact the State regarding the issue and develop a mutually agreed upon resolution, up to and including re-flights the following season.

Through our experience on prior statewide projects, we have learned to expect an average of 10-percent reflights per season because of weather or ground conditions. As part of our project plan, Woolpert will allocate resources and a schedule based on reflights of 10-percent of the total flight lines, and schedule acquisition crews to re-acquire these particular areas prior to leaving the project area. Additional resources are available if a flying season becomes particularly challenging due to weather or ground conditions.

3.2.13 Describe your process to produce and quality check deliverable lidar products.

The lidar deliverable production process begins with the data collected from an airborne sensor. Once acquired, the lidar data undergoes a systematic series of steps to ensure the generation of accurate and high-quality deliverables, in adherence to USGS Quality Level standards. The initial steps involve hydrographic checks, such as running the Hydro Reclass Macro with careful buffer considerations and conducting a Drawing Review to ensure completeness. Verification processes, including checks for vertical variance on lakes and rivers, polygon Z validation, and meticulous examinations for uniform values in vertices, are executed. Hydrologic and bridge breaklines are imported to LAS with overlapping checks, and deliverable breaklines for lakes, streams, and bridges are created. The entire hydrographic dataset is then clipped to the designated project area (DPA) to ensure alignment with project specifications.

The lidar data is then processed for topographic deliverables, beginning with the generation of GeoTIFF DEMs from LAS data. This involves a thorough review, including validation of grid size with the Project Plan and verification of breaklines enforcement using polygons. Edits are made as necessary, and tiles are reproduced if needed. The DEMs are clipped to the DPA, null values are set uniformly, and pixel-level zoom checks are conducted to identify gaps, overlaps, and offsets. Raster data undergoes rigorous scrutiny, encompassing checks for extreme values, null values, and cell size. The lidar data is also processed to create MSHR (Maximum Surface Height Raster) products and intensity imagery products, each subject to its specific QC checks, including interpolation method verification for MSHR and grid size verification for intensity imagery.

Following the completion of lidar data processing, the deliverable production transitions into the formal lidar data quality control phase. This involves a meticulous review of the deliverables, including compliance checks with USGS Lidar Delivery Guide standards. Various steps are taken, such as version verification, withheld flag checks, and bridge cleanup, ensuring the lidar data aligns with the specified project requirements. The lidar data is converted to the final .laz format, and additional processes, such as Las Thin, Las Split, and Las Boundary, are applied to refine the dataset. Shape files are cleaned, merged, and attributed according to USGS standards. Special attention is given to bridge points, ensuring their proper representation in the DEM without intersecting hydro-polygons.

In addition to topographic and hydrographic assessments, the overall lidar data undergoes inter-swath and intra-swath testing, with accuracy statements and shapefiles generated for detailed quality assessments. Vertical testing includes the creation of NVA (National Vertical Accuracy), VVA (Vertical Vegetation Accuracy), and control shapefiles, accompanied by comprehensive accuracy reports. The final stage involves the creation of a geo-package at the time of delivery, utilizing a USGS template and incorporating LAS WKT (Well-Known Text) information. Throughout these combined processes, meticulous attention to detail, compliance with USGS standards, and comprehensive quality control checks contribute to the production of lidar deliverables of the highest accuracy and consistency.

3.2.14 Describe the process to ensure there is an accurate or consistent transition between years of collection.

To ensure a seamless and accurate transition between years of lidar data collection, Woolpert's proposed approach encompasses multiple key strategies. Firstly, each defined annual collection area contains approximately 1.5 linear miles (3 tiles) of overlap with the neighboring collection area(s). These overlapping regions serve as a validation mechanism for the alignment process. By identifying common features in the overlap regions, such as buildings, roads, or natural landmarks, software algorithms can calculate precise shifts, rotations, and scale adjustments to align the datasets accurately. Furthermore, analysts can assess the accuracy of the data registration and make any necessary adjustments to optimize alignment quality by comparing elevation measurements and point cloud characteristics across overlapping areas. This iterative refinement ensures transitions between adjacent datasets are seamless and there are no visible artifacts or discontinuities in the final output.

Leveraging existing ground control from prior statewide projects will establish a foundation of continuity, addressing potential gaps with additional GCPs surveyed by licensed professionals. The documentation and marking of these control points will be meticulously executed, ensuring their visibility and reliability throughout the project's duration. Woolpert emphasizes stringent quality control procedures, conducting internal horizontal accuracy assessments for orthoimagery and vertical accuracy assessments for lidar datasets in adherence to the National Standard for Spatial Data Accuracy (NSSDA) standards. Consistency checks will be implemented to address changes in technology or flight planning, while a well-defined re-visit plan will be executed for unforeseen challenges such as image rejection due to unfavorable environmental conditions or technical issues. Continuous coordination with State authorities, including the Indiana Geographic Information Office (IGIO), will further enhance Woolpert's ability to meet long-term project objectives by addressing emerging issues and incorporating valuable feedback into the data collection process.

By seamlessly integrating existing control points, establishing new ground control with precision, implementing rigorous quality control measures, and maintaining open communication with State authorities, Woolpert's proposed methodology ensures a robust and consistent transition between years of lidar data collection. These measures collectively contribute to the reliability and accuracy of the delivered datasets, instilling confidence in the state of Indiana's comprehensive mapping project over the full project timeline.

3.3 Lake Michigan Coastal Program

3.3.1 Explain your ability to complete the specifications outlined in Section 7.1.3 of Attachment N.

As detailed in Attachment N Section 7.1.2, Woolpert will acquire QL1 lidar and 3-inch orthoimagery for approximately 120 square miles along Lake Michigan annually, to include Year Four (2028). Woolpert will produce a bare earth DEM in addition to the specifications as outlined in Attachment N Sections 7.1.1 and 7.1.2.

Logistically, the Lake Michigan Coastal Program data will be acquired near the end of each flying season to allow for snow and ice accumulation to melt. Like the statewide 6-inch/QL1 base products, the Woolpert team will plan, coordinate, and execute all aerial data acquisition tasks to the State's specification.

3.4 General

3.4.1 In general, explain your proposed project team's ability to complete the Scope of Work Tasks detailed in Section 7 of Attachment N.

Woolpert has detailed, **at the end of this document,** our proposed project team and those individuals expected to be the most involved in the successful performance of work under this contract.

3.4.2 What challenges do you anticipate using the same family of sensors throughout the statewide program (for each county, across all resolutions)?

Woolpert does not anticipate any challenges in using the same family of sensors throughout the statewide program, but rather see this requirement as an opportunity to underscore the successful partnership between Woolpert and Keystone Aerial Surveys (KAS).

Both Woolpert and teaming partner KAS operate sensors from the Leica DMC family (specifically the DMC-3 and DMC-4 models). Though less sensor-dependent than imagery, our partnership also offers topographic lidar synergies via the Leica TerrainMapper and CityMapper line of sensors. Leica products are viewed as industry-leading large format systems for aerial mapping. Both systems use several of the same internal sensor components and share a post processing environment in Leica's HxMap platform. For nearly 20 years, KAS has been a valued subcontractor to Woolpert on the Ohio Statewide Imagery Program (OSIP), having assisted with the aerial data collection on over 50 county, municipality, and special locality projects.

3.4.3 How will you ensure the download and storage of final deliverables through the guarantee period?

Woolpert maintains safe, environmentally controlled off-site storage of all our archived data. This facility is specially designed to warehouse both hardcopy and electronic data. With cloud, colocation, and on-premises data storage capabilities, Woolpert maintains a virtually infinite volume of storage with physical and digital redundancies in place to protect our clients' data in the event of technology failures and real-world disasters at any one location. Woolpert will archive all raw source, intermediate, and final data for a minimum of five years, after which time Woolpert and State staff will determine the next appropriate action.

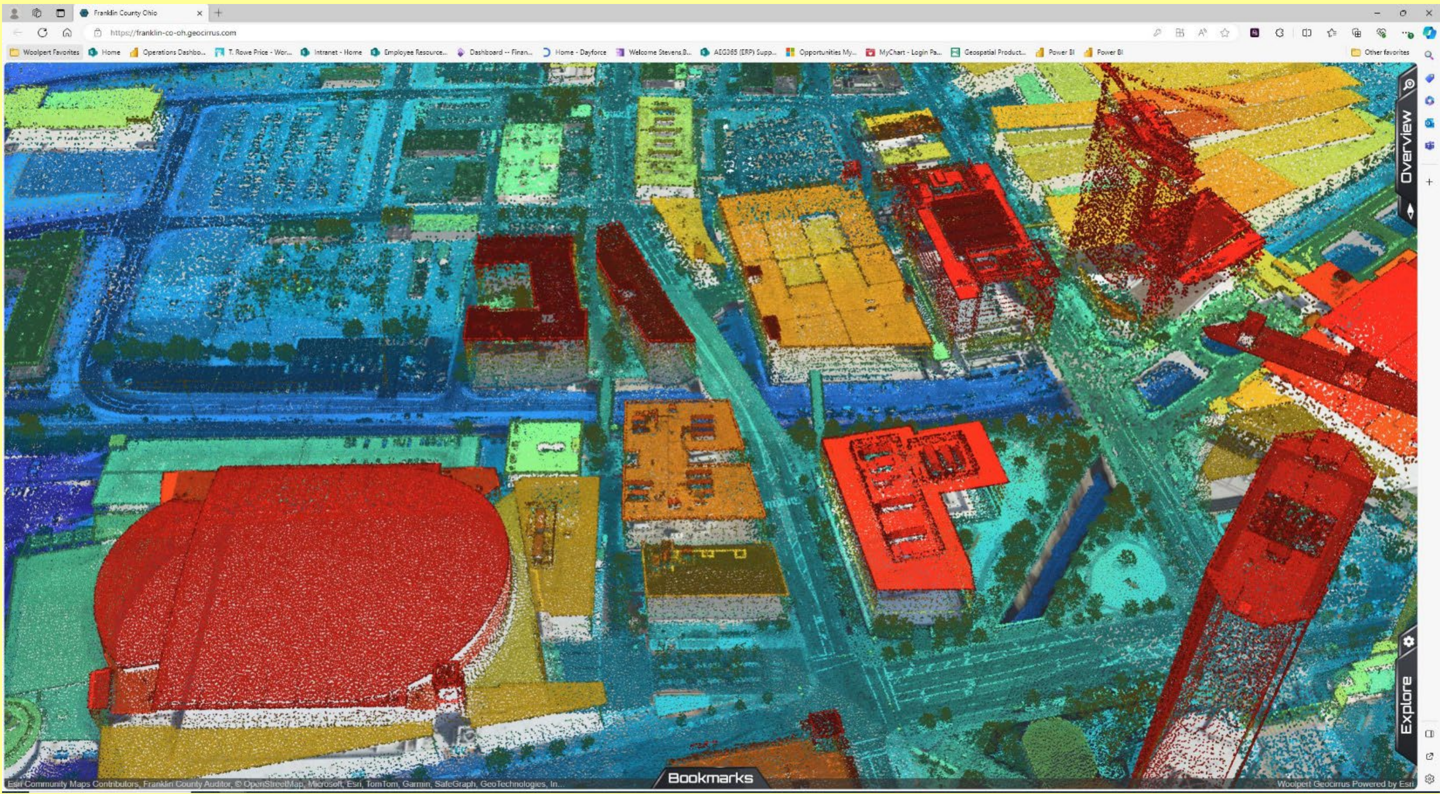
3.4.4 How will you ensure that file naming, file format, file header information is consistent throughout the project?

Woolpert realizes the complexity of delivering large datasets and the difficulty of maintaining consistency over multiple years. For that reason, we have developed specific proprietary workflows, tools, and quality control standards to ensure consistency throughout the project life cycle. The process starts with developing standard formats and naming conventions at the project kick-off meeting between Woolpert and the client. These standards will be defined and documented by Ms. Bowe in the internal project plan. During the internal project kick-off, the project plan is distributed and reviewed by all production team leads and any staff that will be working on the project. The project plan is considered a live document throughout the project lifecycle, any changes, or modifications to the formatting or naming convention is noted and dated by the Project Manager as a change order.

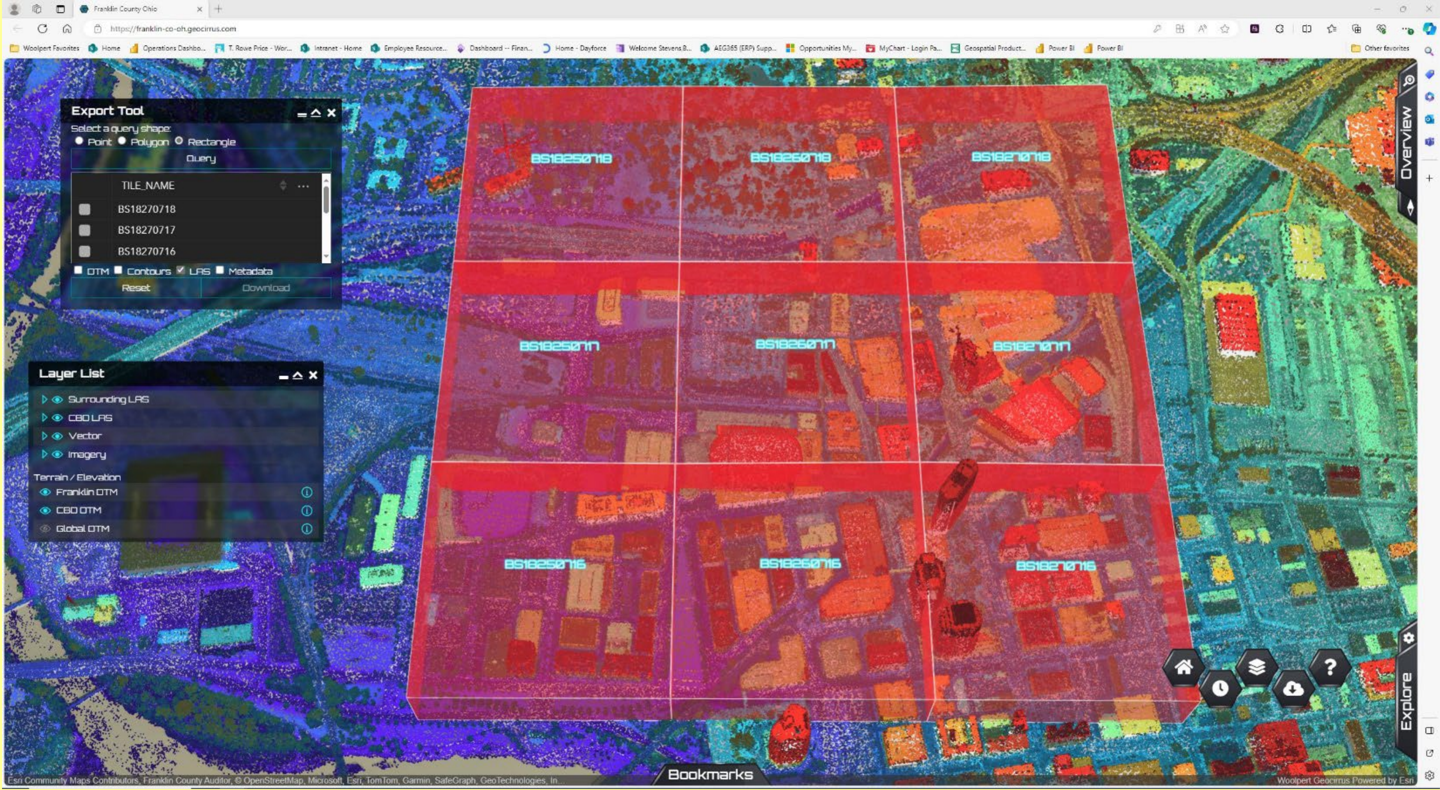
Prior to delivery, Woolpert's quality control group runs several proprietary QC tools that automatically check file naming, formatting, and header information. These QC tools can be customized to recognize specific information or formatting to identify possible errors. These errors are then manually reviewed by the QC staff and corrected as needed for final delivery.

3.4.5 What additional media and process do you propose using for final deliveries?

In addition to our SVC and STREAM:RASTER services, Woolpert has developed a web application for 3D visualization of lidar point cloud data. This application—Geocirrus—brings together various elements of the real world into a virtual environment that provides a unified, holistic, and end-to-end integration to assist administrators, planning agencies, property developers and environmental agencies to plan and manage increasingly complex environments.



The above image provides a depiction of Woolpert's Geocirrus Web-based Application for 3D visualization of lidar point cloud datasets.



The above image provides a depiction of how lidar data (in this case individual lidar tiles) are identified to be downloaded.

Please note while SVC is provided to the Indiana team during their review of the orthoimagery at no cost, there is a cost associated with the use of Geocirrus. If interested, Woolpert would like to discuss options with the state to determine the software's potential implementation.

Woolpert is providing, **as a separate attachment**, additional information on Geocirrus.

4 Optional Buy-Up Deliverables

4.1 Explain your ability to complete the specifications outlined in Sections 7.2 of Attachment N and listed below:

- 3-inch orthoimagery
- 3DHP – 3D Hydrography Program
- 2-foot Contours
- Additional lidar classifications and products
- 2-foot Digital Surface Model (DSM)
- Building footprints
- Planimetric data such as the edge of pavement, road markings, vegetation, etc.
- Impervious cover
- Land use
- Land cover
- Custom geographic boundaries of the base products
- Hydro-flattened waterways wider than 25 ft
- Lidar point density of 25 points per square meter
- 2-foot Normalized Digital Surface Model (nDSM)

- Raw swath data
- Vendor-proposed additional optional buy-up deliverables
- Meta Raster Format (MRF) overviews as a final deliverable along with the COG TIFF files.

Woolpert is providing, as a separate attachment, additional information on **AI/ML innovations** which underscore many of the supplemental products noted in this section.

Utilizing the advancement of our innovative high point-density lidar sensor, Zeus, **Woolpert will provide statewide 3DEP QL1 lidar meeting an average point density of 25 points per square meter (ppsm) for the same fee as the standard 8 ppsm**, in addition to **raw swath data** should the State request it. Our unique approach is to acquire lidar data at the limits of technology-enabled densities for processing to various specifications, increasing the value, longevity, and impact lidar data can provide. By leveraging these technologies, we will go beyond the conventional 8 ppsm standards, offering opportunities for additional density point clouds and derivative products. This initiative reflects Woolpert's dedication to providing the state with enhanced data precision, supporting a wide range of applications including urban planning, environmental monitoring, and infrastructure development. Through our innovative lidar solutions, Woolpert aspires to be a key partner in fostering sustainable growth and informed regional decision-making.

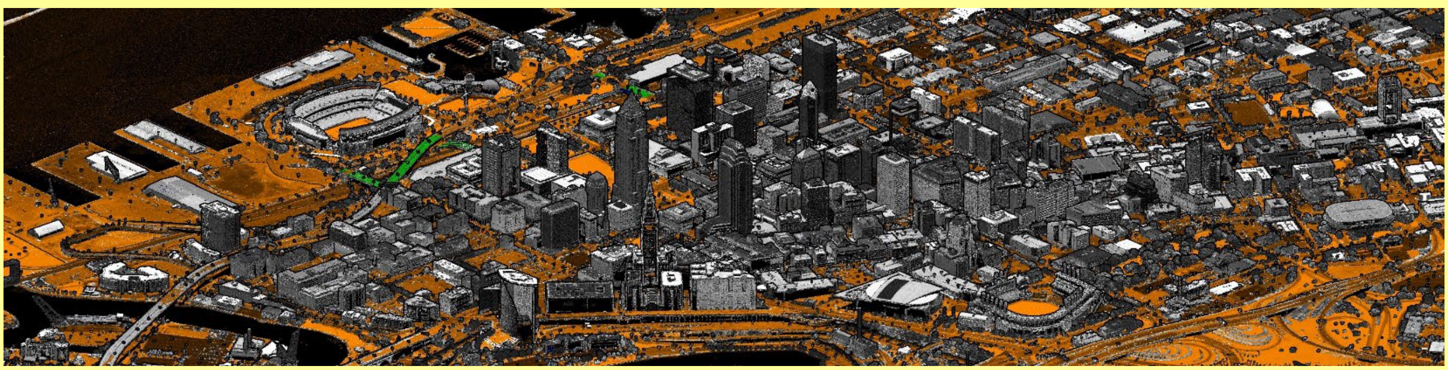
Woolpert will employ the same approach to **3-inch orthoimagery** as proposed for 6-inch orthoimagery in section 3.1 of the Attachment F. Our co-collection flight plan includes the acquisition of statewide 3-inch resolution aerial imagery, resulting in our ability to provide Indiana statewide 3-inch resolution orthoimagery at an extremely competitive price and turnaround timeframe. If the state proceeds with statewide 3-inch orthoimagery, some additional ground control is anticipated, along with a higher level of effort associated with each of the orthoimagery production processes due to a greater volume of collected images.

Woolpert is experienced in producing **3D Hydrography Program (3DHP)**'s elevation-derived hydrography (EDH) that qualifies for NHD and WBD conflation. We are currently performing a USGS task order for approximately 3,000 square miles of EDH in Alaska and completing work for lidar-based EDH in Kentucky, Florida, Tennessee, Idaho, and Ohio. Woolpert leads the industry in the number of staff trained by USGS for EDH editing and conflation. Our proprietary workflows combine automated and interactive mapping to produce complete drainage networks from lidar data and derivative breaklines. The result is a high-resolution, high-accuracy 3D hydrographic dataset with direction of flow: waterbodies and double-line rivers are hydro-flattened with gradient elevation following the immediately surrounding terrain. Single line streams possess a gradient following the immediately surrounding terrain. All hydrographic features are classified and split at intersections. Continuity is complete. When modeled, water released from any point in the dataset will flow to a single outlet.

Woolpert has extensive experience generating 1-foot and **2-foot contours**, including an ongoing effort to produce contours for the entire state of Wyoming. Our contours are systematically derived from input elevation data as opposed to hand-compiled line work, resulting in a more accurate contour layer. Woolpert utilizes multiple tools and software routines to prepare input lidar for contour generation, including the use of key points as well as breaklines to generate the contours. Contours are generated on a tile-by-tile basis and must be joined together to ensure continuity. The contours will then be filtered to remove any small puddles and topology errors will be corrected to ensure no overlaps, intersects, or dangles exist in the dataset. Depending on the size of the AOI, the contours will be split into smaller areas, making it easier for the client to use. Typical statewide deliverables are delivered in a county-by-county basis.

Woolpert commonly produces **additional lidar classifications**, expanded from the USGS Base Specification Classification standard. These often include Low, Medium, and High Vegetation (Classes 3, 4, and 5), Buildings (Class 6), and Road Surfaces (Class 11). With the introduction of Woolpert's high point-density lidar products, we are also able to classify more detailed features such as utility Towers/Poles (Class 15) and Wires (Class 14). Many of these additional lidar classifications are identified using a combination of planimetrically collected features and automated classification routines with the goal of 95% of the points accurately depicting their assigned class. Increased accuracy can be obtained through manual review, editing, and model retraining over time, again dependent on a client's individual requirements.

Digital Surface Models (DSMs) derived from Woolpert's highly accurate lidar data represent both elevations of man-made and natural features. A DSM captures the top-most surface of an area, comprised of all exposed objects including vegetation, building structures, roadway features, etc. After identifying ground points within the collected lidar dataset, interpolation techniques are applied to estimate elevation values for areas between these points. These interpolation methods, which may include triangulation, spline interpolation, or kriging, enable the creation of a seamless surface that accurately reflects the topography of the terrain. The resulting DSM captures variations in elevation, such as hills, valleys, and slopes, while also incorporating the vertical extent of above-ground objects like buildings and vegetation. This integration of ground and above-ground features results in a richly detailed model that faithfully represents the Earth's surface in three dimensions. Depending on the density of the collected lidar dataset, we can tailor the resolution of the generated DSMs to fit each client's needs.



Digital Surface Model (DSM) Produced from High Point Density Lidar

Woolpert has long sought a targeted solution to the problem of lidar exploitation, so we devised and developed a framework, **Automated Building Extraction (ABE),** that uses open-source data toolkits and libraries to detect objects in lidar data, extract them and construct realistic surfaces representing solids within the point cloud. The main goal of this approach was to create a framework that extracts accurate polygons for use as a mapping product in GIS from lidar data of varying densities. Toolkits such as the Point Cloud Library, GDAL, PDAL and libLAS were incorporated in the framework to overcome the challenges of unstructured point clouds and extract planes and edges of physical structures. Open-source tools are highly customizable and enable the detailed investigation of point cloud characteristics and manipulation of modeling parameters to produce robust solutions. This framework has been successfully used on multiple projects to extract building polygons and derive information that could be used in other mapping applications.

Woolpert has extensive experience in extracting **planimetric data** from aerial imagery and lidar through remote sensing methods. Woolpert has extracted thousands of square miles of features using remote sensing techniques. Our unique processes use a combination of COTS software and proprietary programs to develop methods for extraction. Our automated extraction routines are followed by a manual QC review by our remote sensing team to assure the final quality meets or exceeds client expectations. The size and accuracy of the features to be extracted will be dependent on the resolution of the base imagery and lidar for the area selected. Utilizing the latest digital 4-band imagery and lidar, the remote sensing specialist will create a routine capable of extracting the features such as buildings, lakes/ponds/streams, groups of vegetation, paved/unpaved roads, driveways, pavement pads, road markings, sidewalks, and swimming pools.

Woolpert's semi-automated AI/ML feature extraction processes can be used to identify **impervious cover** such as roads, bridges, sidewalks, driveways, parking lots, and patios over a client's area of interest. Remote sensing software and proprietary tools to perform object-based analysis, incorporating imagery and other ancillary vector data. Manual curation will ensure all outputs generated meet project specifications, editing those that do not meet specifications as necessary. The resulting polygons go through a variety of geoprocessing and inspection tools to eliminate errors and ensure file continuity.

Central to Woolpert's **land use** and **land cover** mapping approach is the concept of object-based analysis of both imagery and lidar. Woolpert has developed and successfully implemented a mapping approach that incorporates all available sources of data (4-band imagery, airborne, terrestrial, and mobile lidar) to produce highly accurate land use and land cover maps. This approach is informed by the understanding that technology is always advancing, and we strive to leverage pattern recognition, feature extraction and scene reconstruction techniques in our mapping procedures. Our approach draws on more than 45 years of experience providing mapping services to clients across the country.

Oblique Aerial Imagery. If the State and/or its stakeholders have a need for aerial oblique imagery, we can enlist the services offered by our partner EagleView. Woolpert is currently working with EagleView on the Michigan Statewide Imagery Contract and has also been providing oblique imagery services on the Ohio Statewide Imagery Program for nearly 10 years.

Please note that fees for the optional buy-up deliverables are presented as a flat per square mile fee, which may be discounted based upon factors including population density, terrain and size of the area of interest.

5 Project Management

5.1 Provide a document to describe your company's project management approach and methodology for this project. This should be a high-level document that pulls everything together.

Woolpert is providing, as a separate attachment, additional information on the company's **project management approach**.

5.2 Include here a project management plan, including demonstration of the allocation of sufficient resources to complete all aspects of the work on time and within budget.

Woolpert is providing, as a separate attachment, additional information on the company's **project management approach**.

5.3 Flight mission: include a description of flight planning, aircraft, sensor calibration IMU, motion compensation, camera details and data storage. Address endlap, sidelap, tip, tilt, crab, and flying height.

Please reference section 2.4 above.

5.4 Photogrammetric processing: include a description of processes, technology and software used for image and processing, Analytical Aerial Triangulation, block and bundle adjustment, and residuals.

Please reference section 3.1 above.

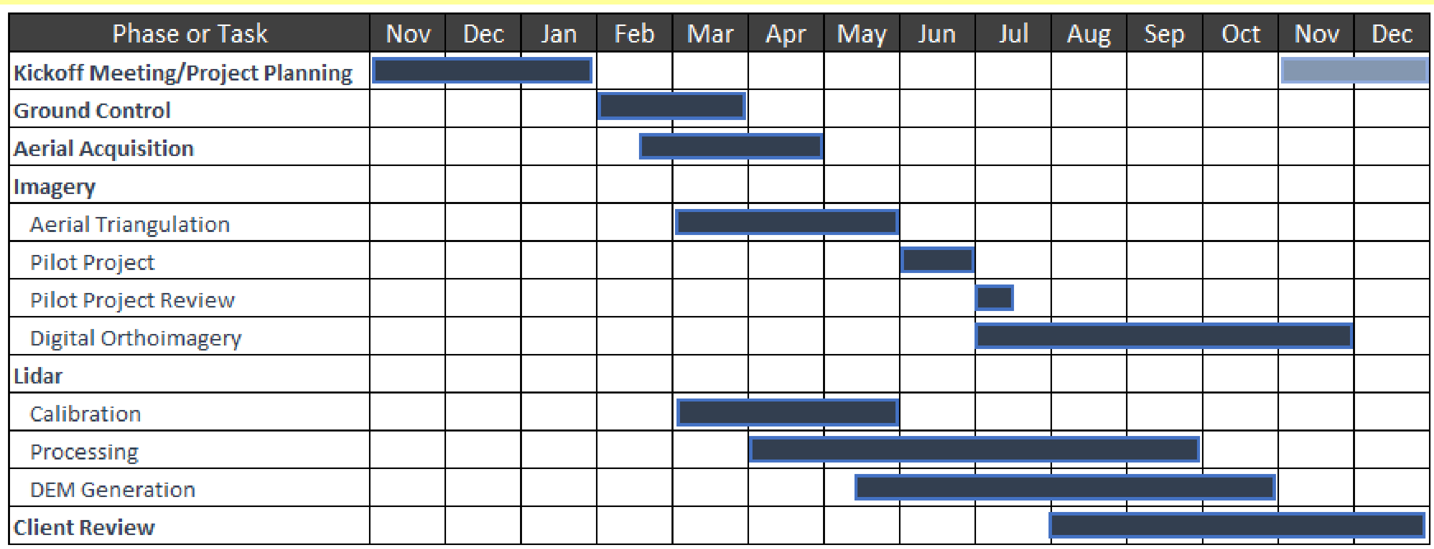
5.5 Lidar processing: include a description of processes, technology and software used for processing the lidar point cloud, Analytical Aerial Triangulation, block and bundle adjustment, and residuals.

Please reference section 3.2 above.

5.6 Delivery schedule: provide a proposed schedule for planning, flight missions, processing, and delivery.

Woolpert understands the State desires to have all final orthoimagery products completed on or before December 31 of the year the imagery and lidar were captured.

The schedule will be similar for each year. An annual schedule is shown in the chart below. Upon completion of aerial data acquisition, Woolpert and the State will prepare a detailed schedule based on project priority. This detailed schedule will also include time set aside for the State's review process. This allows USGS and any additional third-party QA/QC providers the ability to schedule their internal resources needed for the review.



5.7 How would you respond to out-of-cycle flight needs?

Woolpert is familiar with the state of Indiana's previous orthoimagery program and local government entities who participated in the State's buy-up program to higher resolution imagery. We have the necessary staff and equipment to complete the State's imagery and elevation products in a timely manner while remaining flexible to adjust for out-of-cycle acquisition as the need arises.

5.8 Please confirm that you shall provide contact information for an individual or team of individuals that will allow IOT to contact the Respondent's "Point of Contact" anytime during regular business hours.

Woolpert's primary Point of Contact anytime during regular business hours will be our Project Manager Ryan Bowe, GISP, PMP. Program Director Brian Stevens, CP and Production Manager Matt Worthy, PMP will support Ryan throughout the project lifecycle and will also be available anytime during regular business hours.

5.9 Propose your meeting plan and reporting tools to meet the requirements outlined in Section 11.3 of Attachment N.

Kickoff Meeting. Woolpert encourages all our clients to attend the project kick-off meeting at our headquarters in Dayton, Ohio, so State staff get a chance to meet the key individuals involved in the various phases of the project, and the opportunity to tour our production facility. The project kickoff meeting will be scheduled within two weeks after the contract is signed to review the draft project plan. Items to be covered during the project kickoff meeting include the draft project plan, known communities that wish to acquire buy-up deliverables for that year, the project schedule, and a review of anticipated participation by the State, INDOT, USGS, or other staff. Woolpert's project manager will summarize all pertinent issues, clarifications and proposed changes resulting from the meeting and distribute to State staff for approval within five working days after the project kickoff meeting.

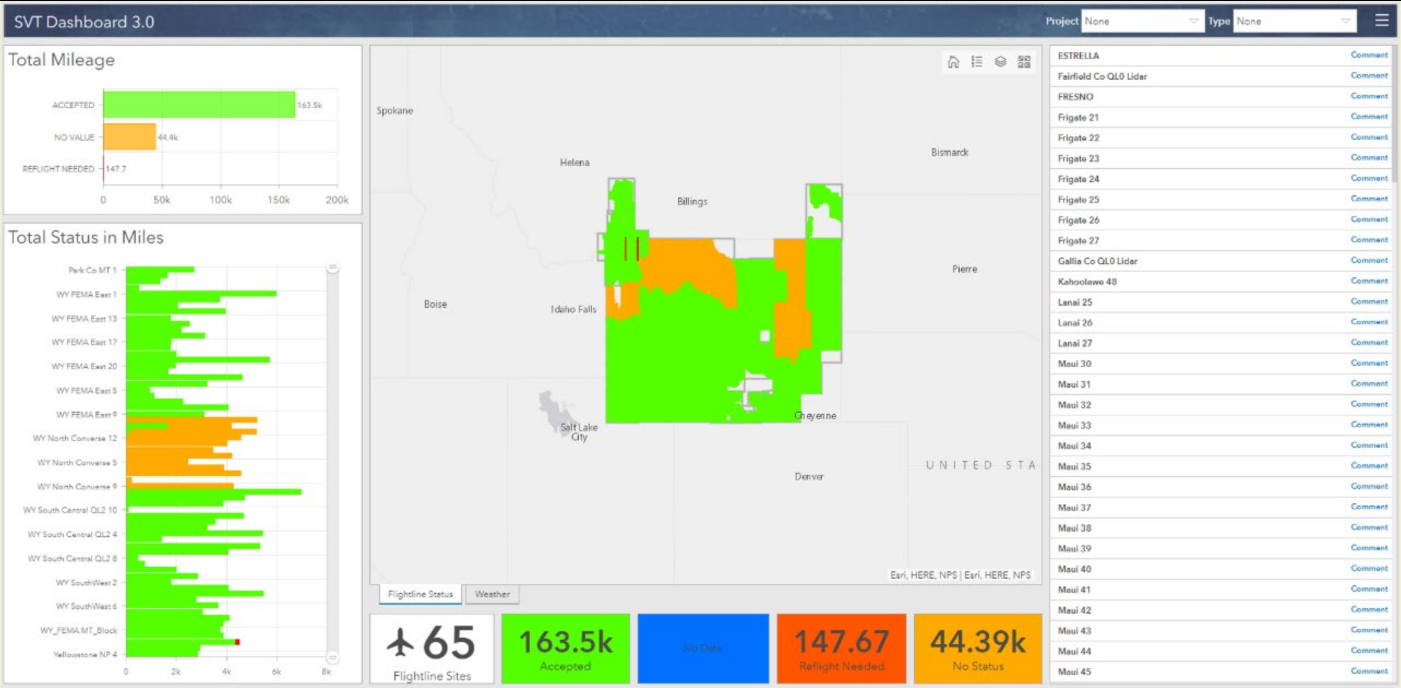
Periodic Status Reporting. During aerial acquisition, the Project Manager will generate a weekly status report submitted to the State indicating flight lines acquired, percentage complete, any issues and anticipated acquisition for the next week. Monthly progress reports will be submitted once orthoimagery production begins and will contain a status of all task requirements – data acquisition, data production, and QA/QC feedback. Upon completion of project tasks, we will conduct our own internal performance evaluation to document lessons learned that can be applied to future projects.

Post-Flight Evaluation Meeting. Within two weeks of the spring flying season's last flight, Woolpert will meet with State staff to evaluate the success of the orthoimagery acquisition and to consider alternatives for gaps where weather conditions or other factors may have precluded successful acquisition of orthoimagery. Woolpert will provide the State several completed and processed sample frames of imagery representative of each set of flight conditions that may affect image quality, from which the State will select the preferred as a template to guide subsequent deliverables. Within 5 working days of this meeting, Woolpert will summarize all pertinent issues, clarifications, and proposed changes and distribute them to the State for approval.

5.10 Describe the tool(s) used to show weekly status updates of flights, data delivery, QA/QC progress and final product acceptance.

SmartView™ Tracker. Woolpert uses a purpose-built web mapping service to constantly monitor and update the progress of our aerial acquisition known as SmartView™ Tracker (SVT) Dashboard. Prior to deploying any aircraft in support of any Client tasking, Woolpert will set up a tasking-specific implementation of SVT for each AOI that Woolpert is awarded. Woolpert will work with the Client and/or other stakeholders to provide access to the site and will be able to monitor the progress of our aerial acquisition immediately in near real time over the internet. The information provided includes but is not limited to:

- The overall flight plan for all acquisition and processing blocks within a Delivery Lot (orange).
- Completed flight lines awaiting QA/QC and acceptance (blue).
- Completed flight lines accepted (green).
- Completed flight lines rejected (red).
- Total status in both miles and kilometers.



State of Indiana "Tracker". As referenced in our Ohio Statewide Imagery Program (OSIP) description, to aid the State and their stakeholders in reviewing the status of their projects via a secure, reliable, and on-demand way, Woolpert architected a "tracker". The tracker is an ArcGIS website used to easily monitor and review the status of the base project and any buy-ups. The website tracks all geospatial projects, including orthoimagery, aerial lidar, traditional photogrammetric, and remote sensing (AI/ML) projects.

To contribute to the success of the Indiana Statewide program, Woolpert will develop a tracker for this program (as illustrated below).