PROFESSIONAL SERVICES AGREEMENT BETWEEN
QUANTUM SPATIAL, INC.
AND THE CITY OF ANN ARBOR
FOR ORTHO IMAGERY AND IMPERVIOUS SURFACE GIS UPDATE

The City of Ann Arbor, a Michigan municipal corporation, having its offices at 301 E. Huron St. Ann Arbor, Michigan 48103 ("City"), and Quantum Spatial Inc. (“Contractor”) a Wisconsin Corporation with its address at 10033 MLK St N, Ste 200, St. Petersburg, FL 33716 agree as follows on this _____ day of _____, 20___.

The Contractor agrees to provide services to the City under the following terms and conditions:

I. DEFINITIONS

Administering Service Area/Unit means **Public Services Area/Systems Planning Unit**.

Contract Administrator means **Craig Hupy**, acting personally or through any assistants authorized by the Administrator/Manager of the Administering Service Area/Unit.

Deliverables means all Plans, Specifications, Reports, Recommendations, and other materials developed for and delivered to City by Contractor under this Agreement

Project means **Ortho Imagery and Impervious Surface GIS Update**.

II. DURATION

This Agreement shall become effective on _____, 20____, and shall remain in effect until satisfactory completion of the Services specified below unless terminated as provided for in Article XI.

III. SERVICES

A. The Contractor agrees to provide *Ortho Imagery and Impervious Surface GIS Update* ("Services") in connection with the Project as described in Exhibit A. The City retains the right to make changes to the quantities of service within the general scope of the Agreement at any time by a written order. If the changes add to or deduct from the extent of the services, the contract sum shall be adjusted accordingly. All such changes shall be executed under the conditions of the original Agreement.

B. Quality of Services under this Agreement shall be of the level of quality performed by persons regularly rendering this type of service. Determination of acceptable quality shall be made solely by the Contract Administrator.

C. The Contractor shall perform its Services for the Project in compliance with all statutory, regulatory and contractual requirements now or hereafter in effect as may be applicable to the rights and obligations set forth in the Agreement.

D. The Contractor may rely upon the accuracy of reports and surveys provided to it by the City (if any) except when defects should have been apparent to a reasonably competent professional or when it has actual notice of any defects in the reports and surveys.

IV. INDEPENDENT CONTRACTOR

The Parties agree that at all times and for all purposes under the terms of this Agreement each Party's relationship to any other Party shall be that of an independent contractor. Each Party will be solely responsible for the acts of its own employees, agents, and servants. No liability, right, or benefit arising out of any employer/employee relationship, either express or implied, shall arise or accrue to any Party as a result of this Agreement.

V. COMPENSATION OF CONTRACTOR

A. The Contractor shall be paid in the manner set forth in Exhibit B. Payment shall be made monthly, unless another payment term is specified in Exhibit B, following receipt of invoices submitted by the Contractor, and approved by the Contract Administrator.

B. The Contractor will be compensated for Services performed in addition to the Services described in Section III, only when the scope of and compensation for those additional Services have received prior written approval of the Contract Administrator.

C. The Contractor shall keep complete records of work performed (e.g. tasks performed/hours allocated) so that the City may verify invoices submitted by the Contractor. Such records shall be made available to the City upon request and submitted in summary form with each invoice.

VI. INSURANCE/INDEMNIFICATION

A. The Contractor shall procure and maintain during the life of this contract such insurance policies, including those set forth in Exhibit C, as will protect itself and the City from all claims for bodily injuries, death or property damage which may arise under this contract; whether the act(s) or omission(s) giving rise to the claim were made by the Contractor, any subcontractor or anyone employed by them directly or indirectly. In the case of all contracts involving on-site work, the

Contractor shall provide to the City, before the commencement of any work under this contract, documentation satisfactory to the City demonstrating it has obtained the policies and endorsements required by Exhibit C.

B. Any insurance provider of Contractor shall be admitted and authorized to do business in the State of Michigan and shall carry and maintain a minimum rating assigned by A.M. Best & Company's Key Rating Guide of "A-" Overall and a

minimum Financial Size Category of “V”. Insurance policies and certificates issued by non-admitted insurance companies are not acceptable unless approved in writing by the City.

C. To the fullest extent permitted by law, Contractor shall indemnify, defend and hold the City, its officers, employees and agents harmless from all suits, claims, judgments and expenses, including attorney's fees, resulting or alleged to result, from any acts or omissions by Contractor or its employees and agents occurring in the performance of or breach in this Agreement, except to the extent that any suit, claim, judgment or expense are finally judicially determined to have resulted from the City’s negligence or willful misconduct or its failure to comply with any of its material obligations set forth in this Agreement.

VII. COMPLIANCE REQUIREMENTS

A. Nondiscrimination. The Contractor agrees to comply, and to require its subcontractor(s) to comply, with the nondiscrimination provisions of MCL 37.2209. The Contractor further agrees to comply with the provisions of Section 9:158 of Chapter 112 of the Ann Arbor City Code and to assure that applicants are employed and that employees are treated during employment in a manner which provides equal employment opportunity.

B. Living Wage. If the Contractor is a “covered employer” as defined in Chapter 23 of the Ann Arbor City Code, the Contractor agrees to comply with the living wage provisions of Chapter 23 of the Ann Arbor City Code. The Contractor agrees to pay those employees providing Services to the City under this Agreement a “living wage,” as defined in Section 1:815 of the Ann Arbor City Code, as adjusted in accordance with Section 1:815(3); to post a notice approved by the City of the applicability of Chapter 23 in every location in which regular or contract employees providing services under this Agreement are working; to maintain records of compliance; if requested by the City, to provide documentation to verify compliance; to take no action that would reduce the compensation, wages, fringe benefits, or leave available to any employee or person contracted for employment in order to pay the living wage required by Section 1:815; and otherwise to comply with the requirements of Chapter 23.

VIII. WARRANTIES BY THE CONTRACTOR

A. The Contractor warrants that the quality of its Services under this Agreement shall conform to the level of quality performed by persons regularly rendering this type of service.

B. The Contractor warrants that it has all the skills, experience, and professional licenses necessary to perform the Services specified in this Agreement.

C. The Contractor warrants that it has available, or will engage, at its own expense, sufficient trained employees to provide the Services specified in this Agreement.

D. The Contractor warrants that it is not, and shall not become overdue or in default to the City for any contract, debt, or any other obligation to the City including real and personal property taxes.

E. The Contractor warrants that its proposal for services was made in good faith, it arrived at the costs of its proposal independently, without consultation, communication or agreement, for the purpose of restricting completion as to any matter relating to such fees with any competitor for these Services; and no attempt has been made or shall be made by the Contractor to induce any other perform or firm to submit or not to submit a proposal for the purpose of restricting competition.

IX. OBLIGATIONS OF THE CITY

A. The City agrees to give the Contractor access to the Project area and other City-owned properties as required to perform the necessary Services under this Agreement.

B. The City shall notify the Contractor of any defects in the Services of which the Contract Administrator has actual notice.

X. ASSIGNMENT

A. The Contractor shall not subcontract or assign any portion of any right or obligation under this Agreement without prior written consent from the City. Notwithstanding any consent by the City to any assignment, Contractor shall at all times remain bound to all warranties, certifications, indemnifications, promises and performances, however described, as are required of it under the Agreement unless specifically released from the requirement, in writing, by the City.

B. The Contractor shall retain the right to pledge payment(s) due and payable under this Agreement to third parties.

XI. TERMINATION OF AGREEMENT

A. If either party is in breach of this Agreement for a period of fifteen (15) days following receipt of notice from the non-breaching party with respect to a breach, the non-breaching party may pursue any remedies available to it against the breaching party under applicable law, including but not limited to, the right to terminate this Agreement without further notice. The waiver of any breach by any party to this Agreement shall not waive any subsequent breach by any party.

B. The City may terminate this Agreement, on at least thirty (30) days advance notice, for any reason, including convenience, without incurring any penalty, expense or liability to Contractor, except the obligation to pay for Services actually performed under the Agreement before the termination date.

C. Contractor acknowledges that, if this Agreement extends for several fiscal years, continuation of this Agreement is subject to appropriation of funds for this Project. If funds to enable the City to effect continued payment under this Agreement are not appropriated or otherwise made available, the City shall have the right to terminate this Agreement without penalty at the end of the last period for which funds have been appropriated or otherwise made available by giving written notice of termination to Contractor. The Contract Administrator shall give Contractor written notice of such non-appropriation within thirty (30) days after it receives

notice of such non-appropriation.

D. The provisions of Articles VI and VIII shall survive the expiration or earlier termination of this Agreement for any reason. The expiration or termination of this Agreement, for any reason, shall not release either party from any obligation or liability to the other party, including any payment obligation that has already accrued and Contractor's obligation to deliver all Deliverables due as of the date of termination of the Agreement.

XII. REMEDIES

A. This Agreement does not, and is not intended to, impair, divest, delegate or contravene any constitutional, statutory and/or other legal right, privilege, power, obligation, duty or immunity of the Parties.

B. All rights and remedies provided in this Agreement are cumulative and not exclusive, and the exercise by either party of any right or remedy does not preclude the exercise of any other rights or remedies that may now or subsequently be available at law, in equity, by statute, in any agreement between the parties or otherwise.

C. Absent a written waiver, no act, failure, or delay by a Party to pursue or enforce any rights or remedies under this Agreement shall constitute a waiver of those rights with regard to any existing or subsequent breach of this Agreement. No waiver of any term, condition, or provision of this Agreement, whether by conduct or otherwise, in one or more instances, shall be deemed or construed as a continuing waiver of any term, condition, or provision of this Agreement. No waiver by either Party shall subsequently effect its right to require strict performance of this Agreement.

XIII. NOTICE

All notices and submissions required under this Agreement shall be delivered to the respective party in the manner described herein to the address stated in this Agreement or such other address as either party may designate by prior written notice to the other. Notices given under this Agreement shall be in writing and shall be personally delivered, sent by next day express delivery service, certified mail, or first class U.S. mail postage prepaid, and addressed to the person listed below. Notice will be deemed given on the date when one of the following first occur: (1) the date of actual receipt; (2) the next business day when notice is sent next day express delivery service or personal delivery; or (3) three days after mailing first class or certified U.S. mail.

If Notice is sent to the CONTRACTOR, it shall be addressed and sent to:

Quantum Spatial, Inc.
Attn: Andrew Brenner, Senior Program Director
1074 Scio Hills Court
Ann Arbor, MI 48103

If Notice is sent to the CITY, it shall be addressed and sent to:

City of Ann Arbor
Craig Hupy, Public Services Administrator
301 E. Huron St.
Ann Arbor, Michigan 48103

XIV. CHOICE OF LAW AND FORUM

This Agreement will be governed and controlled in all respects by the laws of the State of Michigan, including interpretation, enforceability, validity and construction, excepting the principles of conflicts of law. The parties submit to the jurisdiction and venue of the Circuit Court for Washtenaw County, State of Michigan, or, if original jurisdiction can be established, the United States District Court for the Eastern District of Michigan, Southern Division, with respect to any action arising, directly or indirectly, out of this Agreement or the performance or breach of this Agreement. The parties stipulate that the venues referenced in this Agreement are convenient and waive any claim of non-convenience.

XV. OWNERSHIP OF DOCUMENTS

Upon completion or termination of this Agreement, all documents (i.e., Deliverables) prepared by or obtained by the Contractor as provided under the terms of this Agreement shall be delivered to and become the property of the City. Original basic survey notes, sketches, charts, drawings, partially completed drawings, computations, quantities and other data shall remain in the possession of the Contractor as instruments of service unless specifically incorporated in a deliverable, but shall be made available, upon request, to the City without restriction or limitation on their use. The City acknowledges that the documents are prepared only for the Project. Prior to completion of the contracted Services the City shall have a recognized proprietary interest in the work product of the Contractor.

Unless otherwise stated in this Agreement, any intellectual property owned by Contractor prior to the effective date of this Agreement (i.e., Preexisting Information) shall remain the exclusive property of Contractor even if such Preexisting Information is embedded or otherwise incorporated in materials or products first produced as a result of this Agreement or used to develop Deliverables. The City's right under this provision shall not apply to any Preexisting Information or any component thereof regardless of form or media.

XV. CONFLICTS OF INTEREST OR REPRESENTATION

Contractor certifies it has no financial interest in the Services to be provided under this Agreement other than the compensation specified herein. Contractor further certifies that it presently has no personal or financial interest, and shall not acquire any such interest, direct or indirect, which would conflict in any manner with its performance of the Services under this Agreement.

Contractor agrees to advise the City if Contractor has been or is retained to handle any matter in which its representation is adverse to the City. The City's prospective consent to the Contractor's representation of a client in matters adverse to the City, as identified above, will not apply in any instance where, as the result of Contractor's representation, the Contractor has obtained sensitive, proprietary or otherwise confidential information of a non-public nature that, if known to another client of the Contractor, could be used in any such other matter by the other client to the material disadvantage of the City. Each matter will be reviewed on a case by case basis.

XVII. SEVERABILITY OF PROVISIONS

Whenever possible, each provision of this Agreement will be interpreted in a manner as to be effective and valid under applicable law. However, if any provision of this Agreement or the application of any provision to any party or circumstance will be prohibited by or invalid under applicable law, that provision will be ineffective to the extent of the prohibition or invalidity without invalidating the remainder of the provisions of this Agreement or the application of the provision to other parties and circumstances.

XVIII. EXTENT OF AGREEMENT

This Agreement, together with any affixed exhibits, schedules or other documentation, constitutes the entire understanding between the City and the Contractor with respect to the subject matter of the Agreement and it supersedes, unless otherwise incorporated by reference herein, all prior representations, negotiations, agreements or understandings whether written or oral. Neither party has relied on any prior representations, of any kind or nature, in entering into this Agreement. No terms or conditions of either party's invoice, purchase order or other administrative document shall modify the terms and conditions of this Agreement, regardless of the other party's failure to object to such form. This Agreement shall be binding on and shall inure to the benefit of the parties to this Agreement and their permitted successors and permitted assigns and nothing in this Agreement, express or implied, is intended to or shall confer on any other person or entity any legal or equitable right, benefit, or remedy of any nature whatsoever under or by reason of this Agreement. This Agreement may only be altered, amended or modified by written amendment signed by the Contractor and the City. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to be one and the same agreement.

FOR CONTRACTOR

By _____
Type Name

Its

FOR THE CITY OF ANN ARBOR

By _____
Christopher Taylor, Mayor

By _____
Jacqueline Beaudry, City Clerk

Approved as to substance

_____
Howard Lazarus, City Administrator

_____
Craig Hupy, Service Area Administrator

Approved as to form and content

_____
Stephen K. Postema, City Attorney

EXHIBIT A
SCOPE OF SERVICES

(Insert/Attach Scope of Work & Deliverables Schedule)

C. Proposed Work Plan

Objectives of the Project

The City of Ann Arbor wants to update its 2015 imagery with imagery collected in the Spring of 2018. The new imagery will be used as a basis for updating the impervious surface dataset that currently supports the storm water utility.

The City requires the collection of 56.6 square miles of imagery to be captured with an aerial digital camera at a 0.5-foot pixel resolution. Digital orthorectified images will be 4 bands and will include natural color and near infrared bands.

Impervious surface data will be delineated from the imagery for approximately 39.6 square miles. The City requires Pervious, Impervious, and Water polygon features to be delineated and classified to update the existing impervious database. In our proposal below we will outline management methods to ensure that quality control/assurance levels and project schedules are met. Including risk assessment strategies to minimize and resolve production and quality problems quickly to avoid schedule delays. Spatial accuracy issues, content issues, and related quality errors will be identified and corrected before delivering data to the City.

Project Area

The project area is shown in the figure below. The area to be acquired is around 56.6 mi^2 and the area to be mapped for impervious is 39.6 square miles. All acquisition areas are buffered by 100 m to ensure that the whole project area is captured.

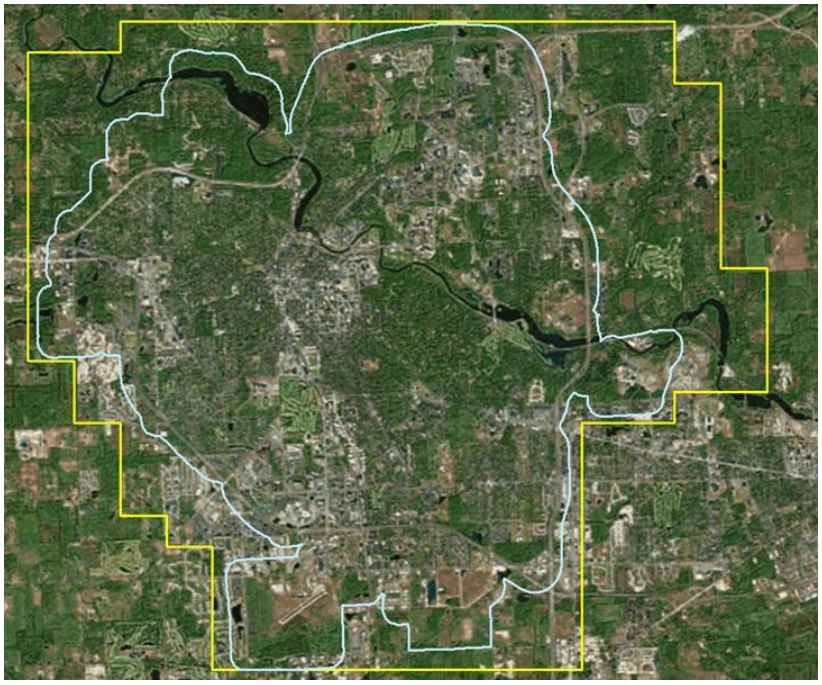


Figure 10: Overview of acquisition area (yellow line) and impervious area (blue line)

Imagery will be collected to the defined project area plus a buffer to ensure complete coverage along the project boundaries, project control points and consistent with project sidelap and endlap. The extent of image coverage will be sufficient to ensure that void areas do not exist within the resulting 2000 ft by 3000 ft tiles provided by the City. It is understood that full image tiles will meet the buffer area described, it is also understood that partial tiles are not acceptable.

Orthoimagery Collection

Quantum Spatial will collect the leaf off imagery in Spring 2018 imagery using our UltraCam Eagle or ADS 100 Sensors. The imagery will be acquired at 6 inch resolution and in 4 bands under leaf off and no snow conditions.

Our planes are based in Sheboygan, Wisconsin and will mobilize to the Ann Arbor when a suitable window opens up, we have in-depth experience getting clearance from busy airports since we have flown over New York and Washington DC, so working with Detroit Metro and Ann Arbor airports will not be a problem. Details on the acquisition plan are provided below.

Digital Aerial Photography Plan

Time and Conditions

Figure 11: Orthoimage from Quantum Spatial's State of North Carolina Orthoimagery program

We will monitor weather conditions 24/7 and plan to fly at times during ideal weather conditions when sun angle meets or exceeds 30 degrees above the horizon. Any mechanical failure, air traffic restriction or other occurrence, which reduces the number of available collection days, will be responded to by a reassessment of schedule, assets and remaining flight lines. We have sufficient capacity with our cameras during this time period to have primary and backup sensor options available. In areas of tall buildings, imagery will be acquired as far as possible at high sun angles (times of approximately 11:00am to 1:00pm) to minimize building shadows. Adjacent flight lines will be flown at sun elevation angles which differ by less than 15 degrees. All imagery will be collected under clear skies - free of clouds and cloud shadows, smoke, dust, and excessive haze. Ground conditions will be monitored in conjunction with the City and will occur when there is minimal flooding, free of snow cover, fog or excessive soil moisture. The ground shall not be obscured by fog. It is also be flown while deciduous trees are free of leaves. Often in Ann Arbor there are conditions when there are piles of snow and leaf out conditions are occurring. Close contact will be maintained with the City to make a decision on the best time to fly under these conditions.

Flight Plan

The Quantum Spatial team begins image acquisition with monitoring of weather conditions to identify daily opportunities for acquisition. Airborne crews are based within the AOI as soon as the season is opened, allowing onsite review of conditions. Numerous data sources are also utilized in identifying daily

acquisition opportunities, including Meteorological Terminal Air Report (METAR) and Terminal Area Forecast (TAF) reports from local airports; cloud cover, temperature, and dew point forecasts from the National Oceanic and Atmospheric Administration (NOAA); and both visible and infrared imagery from NOAA's Geostationary Operational Environmental Satellites (GOES). These data sources are used to identify regions where conditions are favorable for imagery collection.

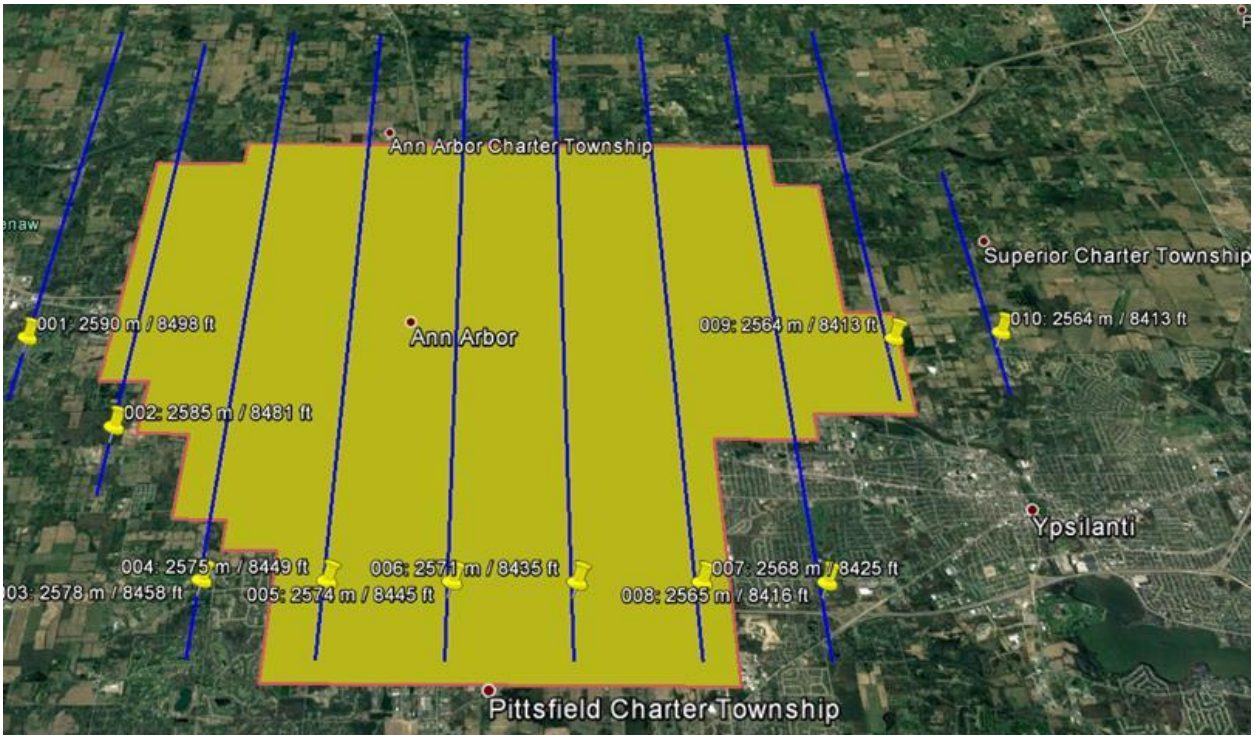


Figure 12: The Quantum Spatial imagery flight plan

Flight plans are filed with the Federal Aviation Administration (FAA) Air Traffic Control (ATC) center responsible for the airspace over the planned collection area. Crews obtain the time window corresponding to the minimum 30-degree sun angle requirement from the U.S. Naval Observatory's Sun Altitude/Azimuth tables. Acquisition missions are launched to ensure the aircrew can be "online" for the first line of the day within five minutes of the sun angle window opening.

Quantum Spatial aircrews ground test the sensor before each mission. The ground test involves booting the sensor control system, recording GNSS/IMU data, initializing the gyro-stabilized mount, and recording image data from the sensor head. These ground tests ensure proper cabling and function of the control, navigation, imaging, and data storage subsystems. Once ground tests are completed, crews launch the image acquisition mission. The pilot performs an in-air initialization of the navigation system, by flying a figure eight pattern, before beginning collection of the first line. After each line is acquired, the pilot makes the turn onto the next line in a teardrop pattern. These flight patterns ensure both left and right turns are made between flight lines, which is critical for collection of the accurate IMU data required for the sensor.

Contiguous survey lines are collected whenever possible. If intermittent or sparse cloud cover is encountered, the full survey line is collected, and any required re-flights planned and acquired as soon as possible. When substantial cloud cover (defined as more than 30% of the survey line being obscured) is

encountered, the line will be aborted and the next clear line identified for acquisition. Imagery will be acquired until weather prevents further acquisition, the sun angle window closes, or the aircraft requires re-fueling. Multiple acquisition missions are performed per day whenever weather conditions permit.

Quantum Spatial aims for at least a 4 hour flying window, this window opens (based on the sun angle) on March 7/8th 2018. Total number of flight hours is anticipated to be < 4 hours.

Re-flights

Quantum Spatial will correct at no additional fee, aerial imagery that does not meet project specifications. All re-flights will be centered on the plotted flight lines and will be taken with the same camera system.

Overlap, Tilt and Crab

Quantum Spatial's planned forward overlap is 60%. The average side overlap will be 40%, with little variance due to terrain within the areas of interest. Additional flight lines may be added over the downtown area to reduce building lean if considered necessary. The Apparent Crab (yaw, pitch, roll) will be ≤ 5 degrees between any two successive exposures. Tilt will be < 3 degrees for any single exposure, < 4 degrees relatives, and < 1 degree overall average.

Aircraft

Turbine and twin piston aircraft are the primary platforms used for imagery collection. The range of cruising speeds for these single or twin engine aircraft are ideal for the flying heights and speeds for imagery collection.

Aerial Camera

Quantum Spatial will operate the UltraCAM Eagle sensor technology to collect aerial imagery. Quantum Spatial owns and operates turbine (Conquest and Commanders) and twin-piston aircraft capable of flying the sensors. The sensor collects full multi-spectral imagery (red, green, blue, and near-infrared).

Airborne GPS and Ground Stations

Quantum Spatial will deploy airborne GPS (ABGPS) and inertial measurement unit (IMU) technologies during the aerial imagery acquisition phases as part of the orthoimage control process. Quantum Spatial staff has more than 15 years of experience in ABGPS control operations including direct geo-referencing. We currently maintain Novatel SPAN GNSS/IMU installed with all our digital sensors. Direct geo-referencing is a powerful technology that combines the strengths of ABGPS for aerial sensor positioning, with an IMU for determining the angular rotation of the aircraft. Quantum Spatial will use existing Continuously Operation Reference Stations (CORS) to differentially correct the ABGPS data. If CORS coverage is inadequate, Quantum Spatial will establish and operate ground base stations during the acquisition phase of the project.

Satellite Geometry & Accuracy

Inertial sensors are inherently very accurate over short periods of time, but exhibit tendency to "drift" over extended periods. Conversely, ABGPS is very stable over extended periods of time, but can exhibit "swings" from one epoch's reading to the next. As a combined inertial technology, the stable nature of

GPS is used to eliminate the drift in the inertial sensors, while the inertial sensors are used to minimize positional changes from the AGPS. GPS satellite configurations are analyzed each morning prior to flight with a current satellite ephemeris, While Position Dilution of Precision (PDOP) is monitored during flight and if an unusual spike is encountered it is dealt with at the time by curtailing acquisition until the spike has passed. Camera perspective centers will be accurate to within 10 cm with the GPS antenna position accurate to within 5 cm.

Flight Reports

Following acceptance of the ABGPS solution, the imagery collection undergoes a final review to ensure that all mission specifications for flight, including crab, tilt, pitch, forward overlap, and side overlap. Any flight lines found to be inadequate will be re-flown at the earliest opportunity. Quantum Spatial will acquire re-flight data with sufficient overlap with accepted images to ensure adequate stereo coverage and data tying to the previously accepted data. When an image acquisition mission has been completed, all imagery and mission documentation will be examined for compliance with project specifications. This testing includes, at a minimum, the following:

- Verify flight plan execution has no gaps
- Check flight line attribution
- Check maximum ABGPS drift parameters
- Confirm complete project area coverage
- Review flight logs, plot of image centers, numbering, spectral content, ABGPS logs, base stations and related data
- Check that all images are present in production network and archive

Ground Control Survey

The Quantum Spatial team will collect photo-identifiable ground control points to support validation of the horizontal accuracy. Quantum Spatial is prepared to also set panels to supplement the photo-identifiable control. Quantum Spatial field crews will complete the control to support the imagery requirements.

Figure 13: Quantum Spatial survey equipment

The Quantum Spatial team uses both real-time correction network (RTCN) and static GNSS surveying techniques to derive coordinates of ground control points. RTCN techniques are implemented in all locations with sufficient network coverage to permit efficient ground control collection. Static techniques are implemented in remote areas where RTCN coverage is not available; ensuring that accurate ground control can be extended anywhere it is needed within the project area. Quantum Spatial uses dual-frequency, survey grade GNSS receivers and antennas, such as the Trimble R-8 or an equivalent, in its survey operations. Each data observation is documented using survey log sheets, and the collected data and log sheets are uploaded to a server for transfer to the production facility. The log sheets and GNSS observations are reviewed to ensure all information required for post-processing is included.

A detailed plan for supplemental ground control solution will be based on the existing reference control provided by the City. These data will be complemented with six new, strategically located ground control points that will serve as a blind check points to verify the absolute positional accuracy of the orthophotography. The new control points will be surveyed to Federal Geodetic Control Subcommittee (FGCS) Second Order, Class II standards for GPS surveys. Quantum Spatial will strategically select from existing First Order GPS control points located within the City to meet the needs of the acquisition. Working with Michigan Licensed Surveyor Kevin Gingras (Michigan Licensed Professional Land Surveyor (no. 49278)) we will make sure that the collecting and setting of the survey control and photo targets, are set at the appropriate accuracies required for the project in areas of dense vegetation where the comparator method cannot provide sufficient control.

Quantum Spatial will include a minimum of 16 ground control points collected between photo-identifiable points and panels to specifically support the orthoimagery requirements. The specific coordinates will be determined based on local access in the field by our field crews along with the consideration of our flight plan layout. The project area would be a single aerotriangulation adjustment and not adjusted in separate blocks that are subsequently tied together. A single adjustment provides the most seamless and highest overall quality solution for the project.

Six independent points will also be collected as requested in the RFP. These are in addition to the 16 described above.

Control Accuracy

The location, density, distribution, and quality of control needed to support a desired final accuracy is dependent on many factors. Some of these factors include the resolution of the acquired imagery, the final deliverable resolution at a desired accuracy standard, terrain, land cover, and the geographic extent of the project area. Digital orthoimagery shall be developed to meet or exceed ASPRS mapping requirements for 1”=100’ (relative accuracy of 1.5 feet).

The quality of inputs such as airborne GPS and IMU data also impact the final ground control requirements. Quantum Spatial will establish a custom control layout and plan based on final deliverables defined in the contract award. This plan will be shared for discussion at the project kickoff meeting. The Quantum Spatial team has experience meeting and exceeding accuracy requirements specified by all levels of government agencies and commercial vendors.

Survey Report

Quantum Spatial will provide a final photogrammetric report detailing the inputs, methods, and outputs from all phases of the project covering any new efforts, including mission planning, ground control survey, image acquisition, elevation surfaces, and accuracy of final deliverables. The survey report will be signed by a Michigan licensed surveyor.

Data Processing

Aerotriangulation

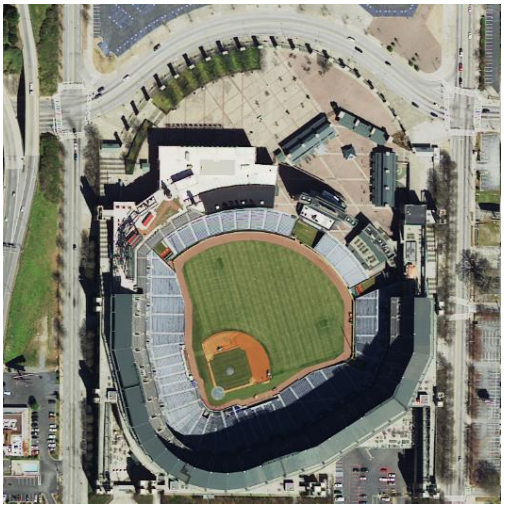


Figure 14: Orthoimage of Turner Field in Atlanta, GA taken

Quantum Spatial utilizes a combination of direct geopositioning from GNSS/IMU navigation systems and least squares block bundle adjustment to derive the aerotriangulation (AT) solution. Kinematic GNSS surveying techniques, along with precise point positioning (PPP) processing techniques, are used to derive coordinates representing the position of the sensor where the processed GNSS positions are combined with the IMU observations. Precise timing data collected during image acquisition allows interpolation of the sensor exterior orientation (EO) at the time of each scan line exposure. The final trajectory and exposure timing data provide the direct geopositioning data used in the Quantum Spatial AT workflow. Direct geopositioning data and L0 image data are applied as inputs to the block bundle adjustment. An automated point measurement (APM) algorithm is run to obtain image coordinate and ground coordinate measurements of common features within the side overlap regions of flight lines. These measurements and the direct geopositioning data provide the observations for the least squares block bundle adjustment algorithm. Ground Control Points (GCPs) are introduced to the processing block for validation of the solution. Once the block solution meets RMSE requirements, it is moved into the orthorectification phase.

Digital Orthoimagery

DEM Use

The best available Digital Elevation Model (DEM) representing the ground surface (e.g., Bare-earth) will be used this is the City Provided LIDAR derived data acquired in 2009. This dataset will be used as the digital elevation data required for this process.

Orthorectification & Image Processing

Quantum Spatial has created a seamless workflow for block bundle adjustment and generation of orthoimages. We take the block bundle adjustment solution and the L0 images as inputs. Processing AT block solutions and orthoimages in a single software workflow eliminate the possibility of EO translation errors, which may be encountered when orthorectification is performed in a separate software package. The orthorectification process consists of:

- Autocorrelation of a digital elevation model as required
- Calculation of atmospheric color correction parameters
- Orthorectification of the L0 imagery
- Validation of relative and absolute accuracy of orthorectified images.

Quantum Spatial applies initial image radiometry corrections during orthorectification. Atmospheric correction parameters are calculated from the multispectral L0 images to be applied during the orthorectification process. Two principal effects are considered, atmospheric haze and bi-directional reflectance. Atmospheric haze describes the effect of sunlight reflecting off of aerosols dispersed in the atmosphere, especially in the blue wavelength of the visible spectrum. Bi-directional reflectance describes the non-uniform brightness of the ground scene in an aerial image caused by varied viewing and illumination angles.

The DEM and atmospheric correction files are added to the block definition. The rectification module is used to generate a natural color (RGB), and/or 4-band orthorectified image strip, known as the Level 2 (L2) format in most workflows. The L2 can optionally be stored in 16-bit GeoTIFF file format, and preserves the atmospheric corrected 14-bit dynamic range of the sensor. The L2 images are validated for relative and absolute horizontal accuracy by visual inspection using Inpho OrthoVista software.

Photogrammetric technicians manually measure common features in the side lap region of adjacent images and photo-identifiable ground control points to validate relative and absolute accuracy of the L2s. With horizontal accuracy validated, the imagery is moved into the mosaicking phase.

Mosaicking of the L2 images is accomplished in Inpho OrthoVista Seam Editor (OrthoVista SE) software. Photogrammetric technicians review and adjust these seamlines using varying steps of automation and heads-up digitization techniques. Manual adjustment is efficient given the minimal number of seams required for the sensor, and allows selective placement of seams where necessary. OrthoVista SE allows technicians to see the resulting mosaic in real-time during editing, minimizing the number edits for seam placement required once tiles are clipped from the mosaic. Validated seams are stored in seam definition files and applied during the tile clipping process in OrthoVista.

Color Correction

An important aspect of any visual interpretation of color balance and associated color correction is proper calibration of the image viewing system. This is achieved through the use of International Color Consortium (ICC) profiles. Quantum Spatial uses specialized software and hardware, to calibrate the image viewing system of computers used for image processing. Calibrations are established to achieve a Gamma 2.0 curve at a color temperature of 6500K.

Quantum Spatial implements color correction of the atmospherically corrected, 14-bit dynamic range L2s, for storage and viewing as 8-bits per channel GeoTIFF images, in the final processing step before individual tile are clipped from the mosaic. L2s generated from the ortho processing block are loaded into OrthoVista to perform the color correction, which allows visual as well as numerical inspection of calculated color corrections in real-time, before the corrections are actually applied to the images. The histogram stretch generally reflects a natural logarithm function; this is necessary to accommodate the way in which the human eye perceives light. Once the histogram stretch has been defined and applied, a simple linear scaling may be performed to arrive at the final 8-bit per channel format.

As a final step, the 4-band imagery (if applicable) is displayed in a false-color infrared representation and reviewed for expected color response in vegetation. The histogram stretch for the near-infrared channel is adjusted as necessary to ensure sufficient differentiation of unique plant species within the sample. The

histogram stretch, once finalized through the above described correction process, is stored in a separate file for each L2 to be applied during the mosaicking process in OrthoVista.

Once color corrections are finalized for a mosaic product, the OrthoVista mosaicking module loads the L2 images, seamline definition files, and histogram stretch files, then outputs color-corrected 8-bit per channel GeoTIFF images corresponding to the extent of the selected tiles. Image quality metrics for luminosity histogram clipping, contrast, and brightness are calculated for each tile. Where necessary, adjustments are applied using image editing software, and are designed to maintain the relative relationship between RGB triplet values achieved in OrthoVista. No major adjustments are applied to the near-infrared image channel.

Metadata

Quantum Spatial will generate Federal Geospatial Data Committee (FGDC) compliant metadata in XML format for digital deliverables. The metadata will be generated from Quantum Spatial internal project documentation as captured in our internal tracking systems during the production process. Metadata files will be named using the predefined naming structure. The completed metadata files will be evaluated using a metadata testing utility to verify proper preparation. The metadata may include a “dataset level” file for each orthoimagery deliverable, and/or “file level” metadata for GeoTIFF tiles and compressed image tiles if applicable.

Quality Control

The Quantum Spatial quality processes begins during the planning phases, including scope review to ensure we can comply with ASPRS requirements and schedule with sufficient capacity, and continue during each phase of the operation through delivery where we use our own scripts to check each file for format and content anomalies.

At Quantum Spatial, our quality control system uses a process-based approach to ensure deliverables meet and/or exceed our customer’s requirements. In a process-based approach to quality, specific processes necessary to perform the project are defined. The inputs and resources necessary to perform the process are identified, along with the expected outputs. Quality checks are performed on each output to ensure it is of sufficient quality to support the project requirements. Metrics derived from quality checks provide feedback reflecting how well each process is functioning, and are used to identify any process adjustments that may be required.

People play an important role in the quality control system, and we empower our employees to take ownership of project quality by training all team members to participate in quality checks. Each employee is given a clear understanding of the quality expectation for the processes they participate in, allowing them to rapidly identify any potential problems and resolve them with minimal impact to the project schedule.

The QA/QC Manager is responsible for the implementation of the quality control system, and provides regular quality metrics to the Project Manager.

Specific Requirements of the Orthorectification Process

i. Resampling: The rectification process will use the cubic convolution resampling technique to ensure high accuracy and image quality.

ii. Mosaicking: The mosaicking process will minimize image distortions and smearing and produce a seamless edge-matched product. Skews greater than one pixel shall be corrected.

iii. Bridge Correction: Breaklines will be captured for above ground features like bridges and overpasses. These will be used to remove image distortions caused by the DTM, which represents the terrain and not elevated features.

iv. Radiometry: Our technical approach to producing radiometry balance is provided above. Images will be color balanced to minimize perceptible Color balancing will result in colors which appear natural to a human observer. Image contrast and brightness will be adjusted to minimize perceptible differences within and between adjacent images.

v. Positional Accuracy: Orthophotography will register to the existing City orthophotography database with final relative accuracies no greater than 1.5 feet.

vi. Quality Control and Assurance: Horizontal accuracy will meet the 1 inch = 100 feet National Map Accuracy Standard.

   a. Visual inspection of geometry will be performed to remove seams, edge match issues, and bridge distortions, excessive building lean and related displacements.

   b. Visual inspection of the mosaic product to correct blurred imagery, inconsistencies in color balancing, color bleeding, and shadow detail.

   c. Random geometric checks for positional accuracy and relative accuracy between tiles.

vii. Image Formats:

   a. Uncompressed GeoTiff image format 8-bit and MrSID image format 8-bit in latest version fully supported by ESRI products.

   b. Presence of compression artifacts from any stages of the production process shall result in rejection of data.

   c. GeoTIFF and MrSID files shall include the tags and keys required to be fully compatible with ESRI products.

   d. Orthorectified images shall be color balanced to the City's preference.

Quantum Spatial runs through these quality check on every acquisition.

Mission Planning Quality

- **Quality Measures:** Completed Mission Plans are reviewed to ensure aerial imagery supporting the intended products can be acquired within the project schedule. Flight plans are plotted against digital elevation models to verify required ground sample distance and side overlap will be achieved. Acquisition scenarios are run to model expected acquisition progress with planned acquisition resources and compared to Acquisition Seasons. Once acquisition begins, actual progress is tracked against planned progress, and resource allocations may be adjusted to account for variances.

- **Inputs:** Project Boundaries, Acquisition Seasons, Contract Specifications, Aircraft Quantity and Characteristics, Sensor Quantity and Characteristics.
- **Resources:** Project Management Team
- **Outputs:** Flight plans, Site Basing Plan, Control Survey Plan

Ground Control Quality

- **Quality Measures:** Survey log sheets are verified for completeness, including instrument setup details, photos, and location sketches. Processing outputs are reviewed for systematic errors, and data is re-processed if necessary using corrected parameters. Data is archived at the production facility for both on-site and off-site storage.
- **Inputs:** Control Survey Plan.
- **Resources:** Field Technicians, GNSS Surveying Equipment, GNSS Processing Software
- **Outputs:** Photo-identifiable Ground Control Point (PID) Coordinates, Survey Log Sheets

Acquisition Quality

- **Quality Measures:** Sensor function is tested before each acquisition mission is launched. Weather forecast data is reviewed to identify areas where imagery meeting contract environmental conditions may be collected. Initial review of imagery for conformance to environmental condition requirements is completed in the field, and re-flights noted in the Master Flight Log. Data Acceptance Reports from the Image Processing Process are reviewed, and re-flights noted in the Master Flight Log.
- **Inputs:** Flight Plans, Site-basing Plans, Weather Forecast Data, Data Acceptance Reports, Contract Specifications.
- **Resources:** Flight Operations Manager, Pilots, Sensor Operators, Aircraft, Sensors, Master Flight Log.
- **Outputs:** Raw Aerial Imagery, Raw GNSS/IMU Trajectory Data, Flight Logs.

Processing Quality

- **Quality Measures:** Flight logs are verified for completeness, including atmospheric conditions, sensor settings, and image acquisition start/stop times. L0 images are reviewed in detail to verify proper sensor function, navigation system function, and conformance to environmental condition requirements. Quantum Spatial Data Checker is used to assist in acceptance and tracking. Data acceptance reports are used to communicate any needed re-flights to the aircrews. Data is archived at the production facility for both on-site and off-site storage.
- **Inputs:** Raw Data, Flight Logs, and Contract Specifications.
- **Resources:** Production Manager, Photogrammetric Technicians, Computer Systems, and Image Download Software.
- **Outputs:** Post Processed Data, Data Acceptance Reports

Aerotriangulation Quality

- **Quality Measures:** GNSS/IMU trajectory data processing results are reviewed for systematic errors and data is re-processed as necessary with corrected parameters. Photo-identifiable points are measured in block AT solutions and compared to PID survey coordinates to verify absolute accuracy of Aero-Triangulation solution.
- **Inputs:** L0 Aerial Imagery, Raw GNSS/IMU Trajectory Data, Sensor Manufacturer's Geometric Calibration, Flight Logs, Flight Plans, Survey Coordinates, Survey Log Sheets, Contract Specifications.
- **Resources:** Production Manager, Photogrammetric Technicians, Computer Systems, GNSS/IMU Trajectory Processing Software, and Aerotriangulation Software.
- **Outputs:** Block Aerotriangulation Solution

Orthorectification Quality

- **Quality Measures:** Autocorrelation results are filtered to remove above ground features and the final DEM reviewed for vertical anomalies. L2 images are reviewed for relative accuracy by measuring features in the sidelap between adjacent images, and absolute accuracy by measuring coordinates in the L2s and comparing to field survey coordinates. Quantum Spatial Image Checker application assists with ortho inspection on large blocks. Any errors identified are reviewed, and edits to the DEM made if necessary to correct.
- **Inputs:** L0 Aerial Imagery, Block Aero-Triangulation Solution, Manufacturer's Radiometric Calibration, Contract Specifications.
- **Resources:** Production Manager, Photogrammetric Technicians, Computer Systems, Atmospheric Correction Software, Autocorrelation Software, Orthorectification Software.
- **Outputs:** Autocorrelated DEM, L2 Orthorectified Imagery

Radiometric Quality

- **Quality Measures:** Seams are manually placed to minimize impact to field boundary determination. Color Corrections are reviewed to verify RGB triplet neutrality. Near-infrared imagery is visually inspected for expected color separation in different vegetation. Clipping, Brightness, and Contrast metrics are reviewed to ensure conformance to contract specifications and visual usefulness. Image coordinates are measured and compared to field survey coordinates to confirm geometric integrity of the orthorectified imagery is maintained in the mosaicked imagery.
- **Inputs:** L2 Orthorectified Aerial Imagery, Contract Specifications.
- **Resources:** Production Manager, Photogrammetric Technicians, Computer Systems, Color Correction Software, Mosaicking Software, Radiometry Validation Software.
- **Outputs:** Tiles, Seamlines

Delivery Quality

- **Quality Measures:** Seamline topology and attribution is verified in GIS software and any errors corrected. Image tags, georeferenced information, and metadata content are validated using Python QC scripts. Prepared hard drives are cataloged to provide a record of what was delivered. Final archives of the delivered products are generated at the production facility for on-site and off-site storage.
- **Inputs:** Tiles, Seamlines, and Contract Specifications.
- **Resources:** Production Manager, Photogrammetric Technicians, Computer Systems, Hard Drives, GIS Software, Image Compression/Mosaicking Software, Python QC Scripts.
- **Outputs:** Tiles, Seamlines, Metadata; stored on hard drive for delivery

Data Review

The data review requirement of the project will be met by Quantum Spatial's inSITE VOICE (Virtual Online Inspection, Checking, and Editing) application, powered by the Quantum inSITE software platform. This platform allows geospatial data end users and vendors to collaborate in real time on large datasets. Cloud-based quality control increases the speed of projects by eliminating shipping and on-site data distribution and reduces costs by eliminating the need for specialized desktop software. inSITE VOICE scales with your team so you can assign QA work to an unlimited amount of reviewers, who can analyze imagery through inSITE VOICE's cross-platform web application. Quantum Spatial's processing team receives instant georeferenced feedback on their work in a standardized format, helping them resolve issues quickly. In inSITE VOICE, the City and Quantum Spatial view the same data at the same time to ensure project perfection in a single pass. The Quantum Spatial platform hosts massive, high-resolution imagery datasets in the cloud. inSITE VOICE users can access imagery for multiple counties or entire states simultaneously, enabling efficient quality control on any size project.

inSITE VOICE allows users to analyze image tiles and make georeferenced quality control calls based on a configurable set of criteria. Users can pass tiles with no visible issues or make calls on individual issues. Users draw bounding boxes around problem areas and categorize their corresponding calls using a selectable set of common issues. They can enter detailed notes and descriptions for later review by a Quantum Spatial's imagery processing team.

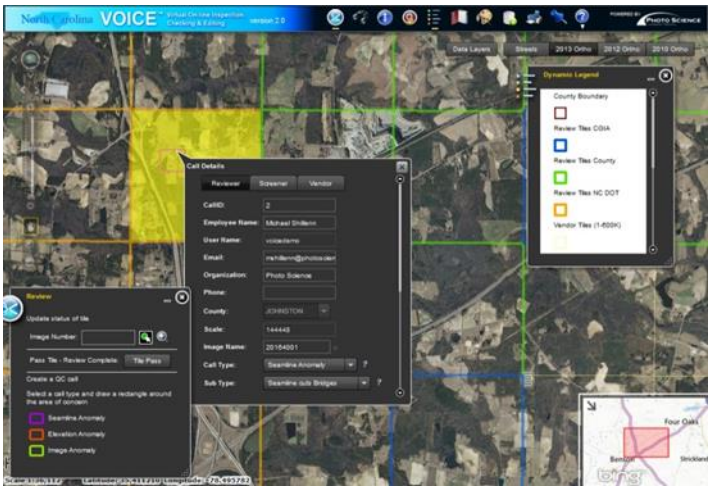


Figure 15: Quantum Spatial VOICE

inSITE VOICE makes your data accessible and available outside the application. Users can export images of individual calls or a GIS-compatible summary of the entire quality control project directly from the web application.

Your quality control team's administrator can add or delete users, reset passwords, and assign appropriate role-based permissions with inSITE VOICE's admin tools. Once your administrator's account is configured, you never have to wait for assistance to make changes to your quality control team.

inSITE VOICE comes with fully featured web-based documentation and support. Your team can access searchable user guides and video tutorials through inSITE VOICE's help center. Users can submit tickets to inSITE VOICE's support team via the help center or email.

Several federal, state, and local entities currently use inSITE VOICE to accelerate and manage quality control for one-time and annual imagery projects. Quantum Spatial can configure inSITE VOICE to support quality control workflows for any type of geospatial data, including LiDAR and large-scale GIS vector datasets. Like all Quantum Spatial inSITE applications, inSITE VOICE receives regular software updates, so existing customers can expect continuous improvement and ongoing development of new functionality.

Quantum inSITE highlights:

- A secure product for review and acceptance of imagery through a OGC WMS imagery service that allows internet access to near lossless full-scale viewing of the orthoimagery.
- It will eliminate the need to ship vast amounts of data on portable media to the City for the purpose of error identification and the verification of corrections.
- It will provide the tools necessary to allow the City to QC the photos, edge-matching, tile names. and geographic placement prior to final physical delivery. It will display Tile boundaries and seamline boundaries.
- It will provide timely access to data processed for this project.
- Imagery on the site will be fully processed and shall have passed the vendor quality control process.
- It allows the City the ability to review orthoimagery, identify and attribute items in-question for discussion with Quantum Spatial.
- The service will be available during the term of the contract.

Impervious Surface Update

Overall Objective

The updated impervious layer will be provided in an ESRI file geodatabase and all features within the updated layer (new, modified and unchanged) will be attributed as described in Table 2 of the RFP. The city will provide the following layers to Quantum Spatial to be used in the analysis

- 2015 impervious surface layer
- Parcel layer, with disputed parcels flagged
- Direct drainage layer (areas not draining into City-maintained storm system)
- Water conveyance layer (natural rivers, creeks, etc.)

The updated impervious surface layer will have, at a minimum, all fields included in Table 2 in the attribute table. All features will be closed polygons that meet standard topology rules and database conventions. Datasets will be provided as one geodatabase, but if tiling is required all tiles will be edge matched.

Quantum Spatial understand that the City will provide a data set of properties that have previously been edited based on customer requests to reduce detected impervious area for bill reductions. These requests were investigated and ground confirmed by City staff. The delivered impervious layer will be created taking special care not to overwrite these edits, only adding impervious area where ground conditions have changed between 2015 and 2018.

Technical Approach

Project Area

The project area will cover an area of 38.5 mi^2 for the City of Ann Arbor.

Source Datasets

We will use existing datasets to support the classification these datasets are listed below.

Source data 2015

- Imagery for both 2018 and 2015 will be required
    - 6 inch pixels
    - 4 band RGB IR

Vector datasets

- 2015 impervious surface layer
- parcel layer, with disputed parcels flagged
- direct drainage layer (areas not draining into City-maintained storm system)
- water conveyance layer (natural rivers, creeks, etc.)

Workflow

Quantum Spatial will provide an update to the impervious surface database leveraging off the original database and being in compliance with its database format. Quantum Spatial is well known for its innovative use of automated processing routines for detecting change, and principal staff proposed for this project have worked on the previous update of the Ann Arbor impervious database. Based on our experience, we believe the most cost-effective approach to creating an update is through a manual interpretation approach. Although a semi-automated change detection approach would provide some information, for the level of detail required by this project and the size of the area being processed, it would be more efficient to use the experience of our compilers to update the dataset using the tool that we use for updating features for federal, state and local governments. This process is described below.

We believe that for this project, the differences between the building lean and shadows between the two sets of imagery, will prevent image to image comparisons. For this aspect of the project Quantum Spatial

will pursue the approach that incorporates a comparison of the impervious coverage with the newly acquired imagery. The 2015 imagery will be primarily used as reference with respect to any errors in the 2015 impervious coverage.

- The project area is divided up into production areas. The first production area will be the Pilot area, with subsequent areas being approximately 5 mi^2 in size. Each production area will be made up of a series of complete tiles. The division into production areas helps organize the data into sequential processing units so that processes can continue in parallel.
- Each analyst will be set up in the same editing environment with the same editing tools and geodatabase. A new field will be generated that identified any changes in the database that are observed. This field will have a pull-down menu with an attribute domain for the change, i.e. new impervious, impervious removed error in 2015 impervious.
- Analysts will first edit in all errors that have been reported to the City during the last three years. These areas will be coded so they are uniquely identified.
- Analysts will review the new imagery with the current impervious surface layer in semi-transparent mode. Production areas will be divided into grid squares that correlate to the scale of the analyst's screen and the scale at which the imagery is to be reviewed (1:1,000).
- Analysts will systematically scan the screen that corresponds to a grid cell, where changes are observed the analyst will edit those changes into an intermediate database and attribute them as either new impervious, impervious removed or error in 2015.
- As a production area is completed the analyst will be responsible for reviewing the common boundary of the analyst's production area and completed production areas, and rectifying any differences between the areas.
- Once all areas are completed, database topology tools will be used to ensure that all topologic issues are resolved (i.e. no overlaps and no dangles).
- The dataset will then be reviewed by a QC analyst who will review the data according to a check list and identify any issues that may have been in the dataset. The review will highlight the areas of change to ensure that they are all correctly delineated; other areas will be reviewed for missed change by integrating the 2015 imagery and the 2018 imagery to produce spectral change signatures. If issues are found then the area will be returned to the production team for review and correction. No dataset will be passed onto the City before it has been determined that it meets the expected standard of the product.
- Once the dataset has been reviewed the attributes in the database will be compressed to impervious, pervious, water and other prior to delivery.
- The City will then have the opportunity to review the data and comment on any issues found.
- All issues raised by the City will be addresses specifically and a final dataset with FGDC compliant metadata will be provided to the City as the final deliverable.

Quantum Spatial will use the file geodatabase provided by the City.

The information on this database is provided below.

Field Name:	**ObjectID** (no NULL values)	
	Field Type:	Number
	Definition:	System generated unique identifier
Field Name:	**PackedPIN** (NULL values allowed)	
	Field Type:	Text (12 characters)
	Definition:	Non-unique Identifier. Values derived from City provided parcel layer. Updated impervious surface layer will be clipped using parcel layer and the corresponding PackedPIN will populate this field
Field Name:	**SurfaceType2018** (no NULL values)	
	Field Type:	Text (40 characters)
	Definition:	Coded Domain
Coded Domain for SurfactType2018		
	Code	**Description**
	Impervious	Impervious surface is defined to mean "a surface that does not permit the absorption of water. Such surfaces are those that water will run off without being absorbed into the surface material."
	Pervious	Pervious surface is defined to mean "a surface that permits the absorption of water. Such surfaces are those that will slow or impede run off of water and promote absorption into the surface material."
	Water	Detention ponds, swimming pools, and other water features not contained in City provided Conveyance layer
Field Name:	**SurfaceType2015** (no NULL values)	
	Field Type	Text (40 characters)
	Definition	Polygons where detected surface is different from detected surface in2018. Coded Domain same as SurfaceType2018

Field Name:	**Conveyance**	
	Field Type	Text
	Definition:	Water polygons intersecting with conveyance polygons in 2015 impervious surface layer. Yes/No
Field Name	**DirectDrainage**	
	Field Type	Text
	Definition:	Polygons intersecting with city provided Direct Drainage Layer. Yes/No

Quality assurance is built into the planning of the project. In a similar manner to the way the imagery is tracked through the process, with each frame being tracked and labeled, the impervious production system conducts a similar effort. Each Production Area is tracked through the process to ensure that no errors creep into the process. This is conducted through tracking the progress with Excel spreadsheets on a SharePoint site, set up for this proposal. The purpose of the tracking sheet is to track progress and make sure each production area goes through the same steps including QC. These checks include the determination of whether the boundaries of the impervious match the boundaries seen on the imagery since the imagery is accurate to the NMAS 1"=100'. Independently 100 change polygons will be assessed against the imagery and the RMS of the error will be calculated.

Quality Control

The objective of our work is a first time right to our clients to ensure that this occurs; all errors need to be identified before the dataset is provided to the client. To this end, we have developed a rigorous quality control protocol that involves both automated and manual review of the production datasets. The quality control team provides feedback to the production team identifying incorrect feature extraction and these items are resolved prior to delivery to the client.

A number of automated and visual QC checks will be performed to check the data accuracy and integrity. The following workflow is used in both the production and QC phases of the project.

Topology Checks: All impervious surface data will meet the topological rules of "No overlap". Additionally, when adjacent features are collected, the topological rule of "Must not have gaps" will be checked. Other topology rules including the following:

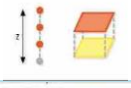
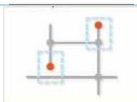
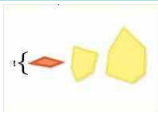
Check Type		
Polygon Overlap / Gap is Sliver Check		Impervious surfaces will not be allowed to overlap any other data layer / Adjacent features must not have gaps between them.
Geometry on Geometry Check		Check for overlapping geometry.
Duplicate Geometry Check		Check for duplicate geometry.
Find Dangles Check		Eliminate dangles for closed polygons
Polygon Sliver Check		All polygons must have a minimum area of 200 square feet

Figure 16: Overview of topology checks carried out by Quantum Spatial on the impervious data layer

Logical Models: An example of the types of logical model that are run is provided below.

"The Building Class must be >= 100 square feet. As part of the requirement for the building dataset, only those buildings greater or equal to 100 square feet will be delineated."

Other logical models can be developed once the rules are discussed with City of Ann Arbor.

Visual Inspections: The visual inspection tools are the last in the verification series and often the most important to detect potential problem areas. These tools allow for physical markup of the feature with a comment about the error detected. Once detected an issue shapefile is provided to the production team to correct, the corrections are then tracked within our system. This system also tracks comments from City of Ann Arbor review. The visual inspection of the impervious dataset will be coordinated with the review of the parcel database.

An example of the tracking spreadsheet that ensures that each production area is reviewed and goes through the same production and QC process is shown in the figure below.

	Quality Control Checklist	
		PA01
1	Create an ArcMap project with the 2003 imagery, 2011 imagery (Tiffs & ecw), 2003 impervious, project boundary, fishnet and any other relevant ancillary data	
2	Create new instance of the QC GeoDatabase for project.	
3	Run "create_editing_layer".gmd to create layer for QC. Class 1 = No Change, Class 2 = imperv removed, Class 3 = new imperv	
4	Pan around at 1:2,000 looking for misclassification. Zoom in as necessary for urban area QC.	
5	Return QC Shapefile, QC'ed file and errata sheet to MIRA for further editing.	
6	Check to see that QC edits have been completed.	
7	If there are a small number of edits not completed as called, complete the edits and finalize by running "convert_qc_layer_to_final.gmd".	
8	Check for data gaps between production areas.	
9	Edge match as necessary with surrounding production areas.	
10	Convert .img file to Grid	
11	Check File name - for delivery files.	
12	Check Projection - for delivery files.	
13	Check to make sure that the data is in binary format	
14	Check attribute table - for delivery files.	
15	Delivery to client	

Figure 17: Example of quality control checklist

Metadata and Report Development: Project-level metadata records will be developed for each deliverable in accordance with the version of the FGDC [FGDC Content Standard for Digital Geospatial Metadata (CSDGM), Vers.2 (FGDC-STD-001-1998)]. Metadata records will be peer-reviewed to identify and correct any typographic or other errors that would not be flagged by automated tools. Metadata will be provided with the project deliverables.

The quality review team will use ArcGIS to quality control the dataset. Metadata will be developed using the Esri Metadata tools.

All data delivered on a USB3.0 HD and labeled using project title, contract number, company info and year of completion.

Deliverables

This proposal provides a detailed product delivery schedule, methodology and project approach, reporting requirements, and compliance with FGDC metadata standards. All spatial data deliverables will meet the spatial reference system standards provided in the RFP Scope of Work Table 1 and described in following RFP sections. All final deliverables will be provided on portable external drives once approved by the City. The deliverables are listed below.

1. Flight Plan and Logs: the flight plan shall be distributed to and approved by the City prior to acquisition. Flight logs shall be provided within two days of each flight acquisition to verify flight times related to sun angle specifications.
    a) Projected flight lines on a map displaying the project area and distributed as a feature class or shapefile suitable for inclusion in ESRI ArcGIS software. Flight lines shall include flight line numbers within the feature attribution, and metadata shall describe the software used to generate the flight plan.
    b) Image centers of each exposure with date and time of acquired photo included. The data shall be distributed as a feature class or shapefile suitable for inclusion in ESRI ArcGIS software.
    c) Upon completion of acquisition, the Contractor shall provide a collection report summarizing the flight and logs.
2. Calibration Reports: Camera and digital sensor calibration reports along with a product characterization report validating USGS Digital Aerial Type standards shall be provided.
3. Survey Control Report: the following information shall be provided in a final survey report.
    a) Positional AGPS data and a statistical summary of the AGPS adjustment results. IMS sensor orientation and a statistical summary describing the overall accuracy of adjusted IMU data.
    b) Differentially corrected GPS ground control data used to supplement the AGPS data and a narrative describing all aspects of the ground survey including locations and extent of the network.
    c) The results and analysis of the constrained least squares adjustment, tables summarizing GPS misclosures, and a description of equipment and software used.
4. Aerial Triangulation Report: an aerial triangulation report shall be provided upon completion of all adjustments. This report shall include the following.
    a) An executive summary of the aerotriangulation solution and its results.
    b) A detailed narrative of the adjustment process and quality checks for accuracy.
    c) A description of the software and equipment used to perform the adjustments.
    d) A listing of the final adjusted coordinates in a spreadsheet or format agreed upon during contract negotiations.
5. Digital Orthorectified Images: All imagery data shall meet the accuracy standards defined in Scope of Work Table 1, the GeoTIFF and MrSID standards defined above, and be submitted via portable external drives. All imagery shall register to the existing City orthoimagery database and meet the image quality standards approved by the City.
    a) Seamless mosaic at 0.5-foot pixel resolution
    b) Edge-matched, non-overlapping tiles at 0.5-foot pixel resolution based on the tile scheme provided by the City and shall register to the existing City orthophotography database.
    c) Images with edge artifacts, mismatch, or voids shall be rejected.
    d) Breaklines used correct bridge and overpass distortion shall be provided in a feature class or shapefile suitable for inclusion in ESRI ArcGISsoftware.

6. Optimized Mosaic Dataset (Optional): Provide the option of also including a mosaic dataset created from the orthorectified imagery.
7. Progress Reports: Progress reports shall be provided by email on a weekly basis aerial photography acquisition until delivery of the pilot project, and bi-weekly thereafter until the project is complete. These informal reports shall consist of a summary of production status, major activities completed during the most recent reporting period, description of issues and corrections, and associated status maps or acquired flight lines.
8. Metadata: Complete FGDC-compliant metadata shall be provided for all data in an XML format. The metadata shall provide a complete description of identification, data quality, spatial data organization, spatial reference, and entity and attribute information. The metadata for orthorectified imagery shall also include acquisition dates.
9. Project Report: A final project report summarizing the flight acquisition, orthorectification process and impervious surface update, quality control and assurance, and deliverables provided shall be provided upon completion of the project. This report shall include a detailed narrative of the analysis, accuracy assessment, and validation of all deliverables.
10. Impervious Data layer: A final impervious Esri Geodatabase as described in the proposal.

Schedule for Delivery

This schedule presented below is a provisional schedule for the delivery of all datasets associated with the project.

Once the project is awarded the Quantum Spatial Project Manager will discuss with the City of Ann Arbor all the deliverables and interim deliverables associated with the project.

	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18
Task	***NTP***								
Project Management									
Image Acquisition									
Ground Survey									
Pilot Orthoproduction									
Installation of VOICE for Pilot									
Sign off on Pilot									
Main Project Orthoproduction									
Internal QC									
Ann Arbor QC									
Sign off on Imagery									
Impervious Surface Development									
Ann Arbor Review of Impervious Surfaces									
Project Sign Off									
	NTP	Notice to Proceed							
		City of Ann Arbor Task							
		Quantum Spatial Task							

Figure 18: Schedule for tasks and sub tasks for the City of Ann Arbor

This schedule above provides a realistic idea of the timeline for the project. This schedule will depend on receiving a notice to proceed by the beginning of February 2018. Quantum Spatial requires a NTP two weeks before acquisition can start. Optimal acquisition period would be between March 8 2018 and April 8 2018.

EXHIBIT B
COMPENSATION

General

Contractor shall be paid for those Services performed pursuant to this Agreement inclusive of all reimbursable expenses (if applicable), in accordance with the terms and conditions herein. The Compensation Schedule below/attached states nature and amount of compensation the Contractor may charge the City:

(insert/Attach Negotiated Fee Arrangement)

1. Fee Proposal

Quantum Spatial is providing in the table below a breakdown of the names, title, raw hourly rates, overhead rates that include the fee, and overall acquisition costs associated with the project.

Our overhead rate covers the cost of staff benefits (insurance and vacation), facility maintenance, administration, and technology support. The multiplier use is 170% of the raw salary and include the fee for the project.

The single value for the aircraft costs and travel expenses cover the cost of the aircraft, fuel, hanger fees, pilot, sensor, sensor operator and crew travel costs.

Staff Name	Title	Raw rate	Hourly Rate	Number of hours	Total Cost
Andrew Brenner	Senior Consultant	$51.79	$139.84	8	$1,118.72
Adam Meyer	Project Manager	$42.69	$115.25	28	$3,227.00
Clay Smith	Orthoimagery Lead	$51.16	$138.14	8	$1,105.12
Doug Logan	Ortho-imagery Production	$47.17	$127.35	8	$1,018.80
Barry Blondell	Orthoimagery Production	$37.87	$102.25	16	$1,636.00
Jonathan Wittman	Acquisition Lead	$40.36	$108.97	16	$1,743.52
Kevin Gingras	Surveyor	$55.56	$150.00	25	$3,750.00
Nathaniel Morton	Impervious Lead	$36.08	$97.42	40	$3,896.80
Various	Image Production Technicians	$21.36	$57.68	120	$6,921.60
Various	Impervious Production Technicians	$17.31	$46.74	60	$2,804.40
Various	inSite Technicians	$33.94	$91.63	40	$3,665.20
Aircraft costs and travel expenses					$7,064.69
Total				**369**	**$37,951.85**

Additional information can be provided if required.

Invoicing breakdown will be as follows.

1. 25% to be invoiced after successful acquisition of imagery
2. 25% to be invoiced after approval of pilot ortho-imagery delivery
3. 35% to be invoiced after approval of full ortho-imagery delivery
4. 15% to be invoiced after approval of impervious delivery

EXHIBIT C
INSURANCE REQUIREMENTS

Effective the date of this Agreement, and continuing without interruption during the term of this Agreement, Contractor shall provide certificates of insurance to the City on behalf of itself, and when requested any subcontractor(s). The certificates of insurance shall meet the following minimum requirements.

A. The Contractor shall have insurance that meets the following minimum requirements:

1. Professional Liability Insurance or Errors and Omissions Insurance protecting the Contractor and its employees in an amount not less than $1,000,000.

2. Worker's Compensation Insurance in accordance with all applicable state and federal statutes. Further, Employers Liability Coverage shall be obtained in the following minimum amounts:

   Bodily Injury by Accident - $500,000 each accident
   Bodily Injury by Disease - $500,000 each employee
   Bodily Injury by Disease - $500,000 each policy limit

3. Commercial General Liability Insurance equivalent to, as a minimum, Insurance Services Office form CG 00 01 07 98 or current equivalent. The City of Ann Arbor shall be an additional insured. There shall be no added exclusions or limiting endorsements which diminish the City's protections as an additional insured under the policy. Further, the following minimum limits of liability are required:

$1,000,000	Each occurrence as respect Bodily Injury Liability or Property Damage Liability, or both combined
$2,000,000	Per Job General Aggregate
$1,000,000	Personal and Advertising Injury

4. Motor Vehicle Liability Insurance, including Michigan No-Fault Coverages, equivalent to, as a minimum, Insurance Services Office form CA 00 01 07 97 or current equivalent. Coverage shall include all owned vehicles, all non-owned vehicles and all hired vehicles. Further, the limits of liability shall be $1,000,000 for each occurrence as respects Bodily Injury Liability or Property Damage Liability, or both combined.

5. Umbrella/Excess Liability Insurance shall be provided to apply in excess of the Commercial General Liability, Employers Liability and the Motor Vehicle coverage enumerated above, for each occurrence and for aggregate in the amount of $1,000,000.

B. Insurance required under A.3 above shall be considered primary as respects any other valid or collectible insurance that the City may possess, including any self-insured retentions the City may have; and any other insurance the City does possess shall be considered excess insurance only and shall not be required to contribute with this insurance. Further, the Contractor agrees to waive any right of recovery by its insurer against the City.

C. Insurance companies and policy forms are subject to approval of the City Attorney, which approval shall not be unreasonably withheld. Documentation must provide and demonstrate an unconditional 30 day written notice of cancellation in favor of the City of Ann Arbor. Further, the documentation must explicitly state the following: (a) the policy number; name of insurance company; name and address of the agent or authorized representative; name and address of insured; project name; policy expiration date; and specific coverage amounts; (b) any deductibles or self-insured retentions which shall be approved by the City, in its sole discretion; (c) that the policy conforms to the requirements specified. Contractor shall furnish the City with satisfactory certificates of insurance and endorsements prior to commencement of any work. Upon request, the Contractor shall provide within 30 days a copy of the policy(ies) to the City. If any of the above coverages expire by their terms during the term of this contract, the Contractor shall deliver proof of renewal and/or new policies to the Administering Service Area/Unit at least ten days prior to the expiration date.