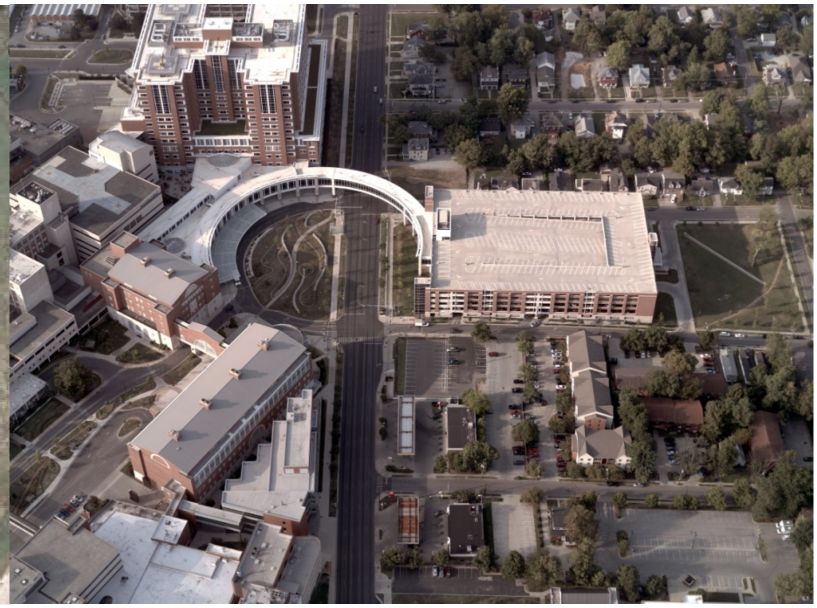
2015 ORTHOPHOTOGRAPHY PROJECT

April 23, 2014

Prepared exclusively for:

Southeastern Wisconsin Regional Planning Commission
ATTN: John McDougall, GIS Manager
W239 N1812 Rockwood Drive
Waukesha, WI 53187

Prepared by:

Jeffrey B. Stroub, CP, PLS, PPS, SP,
Vice President Business Development
920-803-5816 | jstroub@quantumspatial.com

April 25, 2014

Southeastern Wisconsin Regional Planning Commission
ATTN: John McDougall, GIS Manager
W239 N1812 Rockwod Drive
Waukesha, Wisconsin 53187

Dear Mr. McDougall:

Quantum Spatial, Inc. (QSI) [formerly known as Aero-Metric, Inc. (AMI) is pleased to submit our technical and fee estimate offering in response to your Request for Proposal dated February 27, 2015. We believe our company is uniquely qualified to fulfill all your contractual requirements. QSI has been preparing nearly all the Commissions Geospatial service items used in your daily operations under continuous annual contracts since 1980. Our 34 years of continuous service for the Commission has allowed our firm to work closely and interactively with your staff to introduce emerging technologies and implement projects employing said technologies. The following outline briefly summarizes the diversified cross-section of geospatial services QSI has introduced to the Commission and continued to enhance via technological developments to date.

- We began our association with the Commission in 1980, completing conventional topographic base mapping for portions of each of the seven Counties served by the Commission, via traditional analog Photogrammetric technologies.

- During 1986 we introduced the use of Global Positioning Technologies for use in establishing position and elevation upon specified Public Land Section Corners (PLSS). Similar contracts have continued intermittently throughout the decades, with precision coordinates and elevations being established upon thousands of section corners. Sixty contracts for completion of high precision surveying have been completed to date. These programs have also included special network survey re-adjustments, precision leveling and obstruction surveying for Mitchell Field. QSI also worked under the direction of the Commission to complete map accuracy testing for analog and digital map service items.

- During 1992 black-and-white orthophoto imagery technologies were introduced by QSI to the Commission, with large scale pilot projects being completed for multiple areas. The technologies were accepted and the first region-wide color orthophoto program was completed during 1995 utilizing film based technologies.

- During 1994 digital scanning of analog hard copy mapping was undertake to convert existing mapping in Milwaukee County for use within the MCCAMLIS Program.

- During 2005 and 2006, QSI completed large scale digital topographic base mapping for Milwaukee County based upon MCCAMLIS specifications.

- Upon the acceptance of the large scale digital base mapping program for Milwaukee County, digital base mapping has been continuously expanded for various portions of the Commission's jurisdiction in Dodge, Kenosha, Racine and Washington Counties.

- In 2005, QSI completed the first Region-wide color digital orthophoto projects utilizing the then newly introduced Digital Mapping Camera technologies. These service items met with the immediate approval of the Commission's constituents.

- During 2006 QSI introduced Airborne Light Detecting and Ranging (LiDAR) technologies to the Commission. Washington County was the first County-wide LiDAR program completed for the Commission. Bare-earth terrain services and digital contours were processed for the project areas. The terrain surfaces were subsequently used to facilitate future high resolution digital orthophoto imagery programs for the project areas.

- By 2007, the 2005 digital orthophoto service items were in wide use by the Commissions constituent's, and the program was repeated for specific areas during said spring flight period.

- During the 2007 digital imaging program QSI also introduced the first oblique imaging and viewing technologies to the Commission. A pilot area encompassing portions of Milwaukee, Ozaukee, Washington and Waukesha Counties was completed. Digital oblique imagery, viewing software and training was provided to the Commission for evaluation and distribution among the affected constituent agencies.

- During 2009 Racine County contracted for a County-wide LiDAR program. Ozaukee County was completed this same year under a program for a Federal agency.

- By 2010 substantial interest in varying pixel resolutions of orthophoto imagery had grown and the Commission contracted with QSI to completed multiple imagery acquisitions during the spring of 2010 to facilitate a combination of 1-ft, 0.5-ft and 0.25-ft pixel color digital orthophoto programs for specific Counties and municipalities within the region.

- 2010 was also landmarked by the first county-wide high accuracy LiDAR project. Kenosha County was completed with very low altitude LiDAR to support 1-ft contour generation as well as 0.25-ft high resolution color digital orthophoto imagery.

- During 2013 a program was introduced to continue the provision of large scale topographic mapping for specified areas of Walworth County. Our LiDAR and digital imagery sensor technologies are combined to yield the end digital service items in the Counties proprietary Geodatabase format. This successful program is being undertaken again during 2014.

Each time a new technology has been introduced to the Commission, rigid evaluation and accuracy testing has been undertaken by the Commission to ensure the delivered service items met the accuracy and completeness specifications set forth by the Commission. Passing all inspection and testing, the technologies and service items developed in conjunction with the Commission over the past thirty-four years have become the standard work tools which the Commission utilizes to perform their daily regional studies and GIS related services for their constituents.

Our proposed scope of services associated with the 2015 project builds upon the tried and accepted technologies, while introducing the latest state-of-the-art airborne digital sensors. These digital sensors include our UltraCam Eagle large-format vertical mapping sensor, our Leica Trio Oblique imaging sensors, and Leica ALS-70 LiDAR Sensors. All services offered in conjunction with the 2015 program shall again be completed by equipment owned by our firm, and operated by our full time, highly competent technical managers and staff.

Sincerely,

Jeffrey B. Stroub

Jeffrey B. Stroub, CP, PLS, PPS, SP
Vice President Business Development

TABLE OF CONTENTS

1. COMPANY OVERVIEW

Quantum Spatial, Inc. (Quantum Spatial) was created with the goal of being the leader in providing clients with authoritative geospatial solutions worldwide. This leadership came from the recent merger of three world-class geospatial companies (AeroMetric, Photo Science, and Watershed Sciences) to form Quantum Spatial. With over 500 employees that specialize exclusively in geospatial services, and with offices located throughout the Continental United States and Alaska, Quantum Spatial has a broad client base and the capability to provide a wide range of services across the entire geospatial lifecycle. These services range from data acquisition, feature extraction and remote sensing, to analysis, applications and enterprise geographic information systems (EGIS).

What differentiates Quantum Spatial is the collective experience and capacity of our staff, commitment to leading future industry innovation, and ability to leverage key future technology advancements from many different sources.

Quantum Spatial (as AeroMetric) has been a stakeholder in Wisconsin since 1969. With our corporate headquarters in Sheboygan, our company and our employees have invested in supporting the needs of clients throughout the State. We have maintained a demonstrated record of performance in the management, collection, and process of digital orthophotography, Light Detecting and Ranging (LiDAR), and other geospatial data collection and processing technologies (e.g. oblique's).

We began our association with the Commission in 1980, completing conventional topographic base mapping for portions of each of the seven Counties served by the Commission, via traditional analog Photogrammetric technologies. This combined experience provides the Southeastern Wisconsin Regional Planning Commission (Commission) with a company who has an in-depth understanding of the requirements for aerial photography and LiDAR mapping programs throughout the State of Wisconsin. What differentiates Quantum Spatial from other firms is the collective experience and capacity of our staff, commitment to leading future industry innovation, and ability to leverage key future technology advancements from many different sources and vendors.

1. HISTORY

Initially, Quantum Spatial contracted for aerial photography. In 1977, the firm completed the purchase of its first aerial camera-ready aircraft, a 1959 Rockwell Aero-Commander. Additional aircraft have come and gone since that time, leading to the current complement twenty-four (24) specially equipped planes strategically located across the United States. Our company has led the way for the industry in four significant applications. In 1970, Quantum Spatial introduced the use of natural color film for photogrammetric applications in place of traditional black-and-white panchromatic film.

In the late 1980s and early 1990s, Quantum Spatial developed specialized hardware and software applications to generate digital orthophoto and to conduct photogrammetric compilation in a softcopy environment. We completed some of the first statewide Digital Orthophoto Quads (DOQQ) projects using Quantum Spatial's own software, which was developed several years in advance of orthorectification software being commercially available.

In the late 1990s, Quantum Spatial offered airborne 4-band digital imagery to its customers using the Digital Multi-Spectral Video (DMSV) system by SpecTerra Ltd. Success with this system led to the acquisition in 2004 of the first Z/I Imaging Digital Mapping Camera (DMC) in North America. Quantum Spatial worked closely with the US Geological Survey (USGS) and the National Aeronautics and Space Administration (NASA) to provide sample DMC data for the development of digital camera manufacturer certifications. Success with this device was immediate; Quantum Spatial added a second DMC in 2006 and a third in 2010.

Quantum Spatial first began working with laser range finding devices in the 1980s. Successes with this emerging technology led to the lease of Light Detection and Ranging (LiDAR) sensors in the 1990s. In 2004, Quantum Spatial purchased two cutting-edge LiDAR systems by Optech, Inc. These systems were upgraded to the current state-of-the-art configurations in 2008, with multi-pulse technology, recording first, second, third, and last returns.

2. OFFICE LOCATIONS

Quantum Spatial's headquarters in Sheboygan, Wisconsin is also one of our production facilities. Our other production facilities are in Dulles, Virginia; Maple Grove, Minnesota; and Anchorage, Alaska. We also have other offices throughout the United States, including throughout Pennsylvania; Austin, Texas; Portland, Oregon; Lexington, Kentucky; Emeryville, California; Colorado Springs, Colorado; St. Petersburg, Florida; Norcross, Georgia; Mission, Kansas; Chesapeake Beach, Maryland; and Ann Arbor, Michigan. Our office locations are further detailed in Figure 1.

Figure 1: Map of Quantum Spatial Office Locations

3. EQUIPMENT RESOURCES

Quantum Spatial offers a significant amount of resources available for the Commission to complete 2015 Orthophotography Project. All of the equipment listed in Figure 2 are owned and operated by Quantum Spatial.

Figure 2: Quantum Spatial Equipment Resources			
Aircraft			
Qty	Type & Spec	Qty	Type & Spec
1	Cessna Conquest (Twin Engine Turbine)	1	Shrike Commander (Twin Engine)
1	King Air E90 (Twin Engine Turbine)	1	Cessna 402C (Twin Engine)
1	Aero Commander 840 (Twin Engine Turbine)	1	Cessna 310 (Twin Engine)
2	Aero Commander 690 (Twin Engine Turbine)	1	Cessna 320 (Twin Engine)
3	Cessna Grand Caravan (Single Engine Turbine)	1	Cessna 210 Centurion (Single Engine)
5	Piper Navajo (Twin Engine)	6	Cessna 206 Stationair (Single Engine)
Digital Imagery Sensors			
Qty	Type & Spec	Qty	Type & Spec
1	Vexcel UltraCam Eagle Digital Mapping Camera	1	Leica RCD 30 Oblique Digital Mapping Camera
1	Vexcel UltraCam X Digital Mapping Camera	1	Leica Trio Oblique Digital Mapping Camera
8	Z/I DMC I Digital Mapping Camera	1	Phase One
2	Leica RCD 105 Oblique Digital Mapping Camera	1	Applanix DSS 439
High Accuracy Mapping Systems			
Qty	Type & Spec	Qty	Type & Spec
1	Optech Orion C	1	Riegel VQ-480i / Phase One (MiDAR or HAMS)
LiDAR Scanners			
Qty	Type & Spec	Qty	Type & Spec
4	Leica ALS 70 LiDAR Scanner	4	Leica ALS 50 LiDAR Scanner
1	Leica ALS 60 Scanner	4	Optech Gemini Scanners
Thermal Scanner			
Qty	Type & Spec		
1	FLIR SC 6000 QWIP Thermal Infrared Scanner		
Mobile LiDAR System			
Qty	Type & Spec		
1	Optech Lynx Mobile Mapping System		
Film Cameras			
Qty	Type & Spec	Qty	Type & Spec
1	Zeiss RMK A	5	Zeiss RMK Top
Digital Imagery Processing			
Qty	Type & Spec	Qty	Type & Spec
2	Airborne Sensor Management Systems	3	Applanix POS PAC
12	Applanix X-Track	3	Digital Image Analyst
1	Image Station Mission Planning Report	4	Post Processing System Server
8	Z/I In-Flight		
LiDAR Data Processing			
Qty	Type & Spec	Qty	Type & Spec
6	ALS 50 Post Processor	1	TerraMatch Software
10	Optech DASHMap	6	TerraModeler Software
3	Bentley MicroStation	35	TerraScan Software
3	Dell Precision P4 Duel Processor 4GB RAM	1	TerraScan Modeler
1	FME	10	TerraSolid

Figure 2: Quantum Spatial Equipment Resources			
5	GeoCue Software	27	GeoCue (NIIRS 10)
2	LP360 EQC Software	25	CUES
3	QT Modeler Software	2	ALTM-NAV
Photogrammetry/Orthophoto/GIS/CADD			
Qty	Type & Spec	Qty	Type & Spec
6	Boeing KDSP Softcopy Workstations	23	AutoCADD Licenses
51	Boeing SoftPlotter Softcopy Workstations	77	Bentley MicroStation Licenses
34	SOCET SET	1	ECW License
12	Intergraph SSK Softcopy Workstations	6	ERDAS Imagine Licenses
26	SOCET SET Digital Softcopy Workstations	18	GeoMedia Licenses
19	Digital Orthophoto Workstations	52	Global Mapper Licenses
4	Intergraph ISAT AT Workstations	1	Inpho OrthoVista Licenses
4	Kern First-Order DSR-14 Analytical Stereoplotters	1	Intergraph MGE GIS Licenses
1	Kern First-Order DSR-15 Analytical Stereoplotters	1	Definiens eCognition Developer
6	KLT Atlas Digital Data Analytical Capture Systems	4	PixelQue
5	Qasco Analytical Stereoplotters	9	Intergraph SSK Software Suite Licenses
3	Zeiss P-3 Analytical Stereoplotters	1	Definiens eCognition Server
19	IRASC Licenses	5	ALBANY (ERIO Technologies, PatB (INPHO-TRIMBLE)
2	MicroStation InRoads Licenses	1	BINGO
7	MrSID Licenses	8	ImageStation ISAT and/or MATCH-AT
74	Esri ArcGIS Licenses	35	GeoMedia and/or ImageStation OrthoPro
70	Esri ArcView Licenses	8	Photoshop CS3 5 & 6
1	Esri ArcGIS Server Licenses	2	AutoCADD Civil 3D Licenses
1	Esri ArcIMS Licenses	2	Carlson Survey 2012 w/IntelliCAD 7.1
Surveying			
Qty	Type & Spec	Qty	Type & Spec
38	Trimble/Leica Dual Frequency GPS Receivers	1	Trimble R6 GLONASS RTK Rover Kit
8	Leica/Zeiss/Sokkia Auto Levels	4	Trimble R8 GLONASS RTK Rover Kit
14	Leica/Trimble/Topcon Total Stations	1	Trimble R10 GLONASS RTK Rover Kit
23	Survey Vehicles	12	Trimble R7 GLONASS Bases
4	Trimble Geomatics Office (TGO) Software	6	Trimble R7 GPS
6	GeoLab 2	3	Leica CS15 GPS RTK Rover Kit
4	Pegasus-EX Portable Weather Stations	1	Leica CS10 Viva NetRover RTK

2. KEY PERSONNEL

Each of the key personnel selected for this project has extensive relevant experience and outstanding professional qualifications. Our team's assigned key personnel for this project has an average of 25 years of experience. All phases of work performed in support of this project will be supervised by Certified Photogrammetrists, a Certified GIS Professional, and a Wisconsin Registered Land Surveyor. An organizational chart for the team is provided below (Figure 3) illustrating the project organizational structure and roles of our key staff. Resumes for all of our key personnel are included on the pages following the organizational chart.

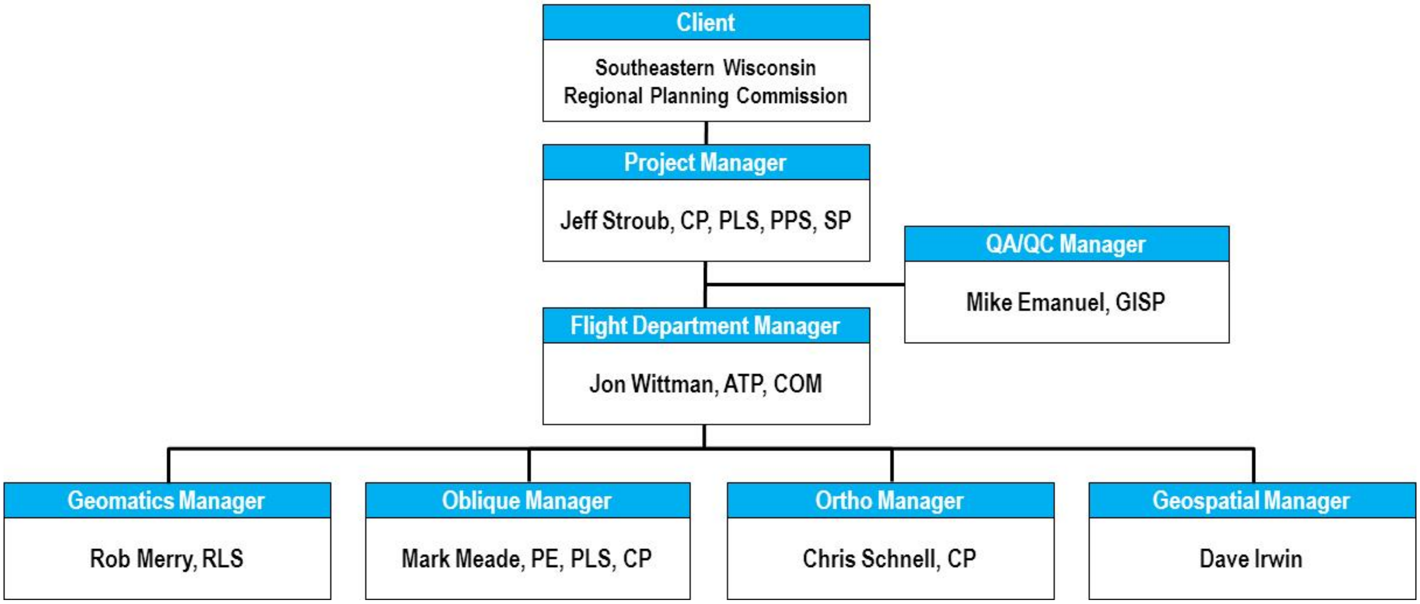


Figure 3: Organization Chart

Jeff Stroub, CP, PLS, PPS, SP

In his role as Vice President Business Development, Jeff directs all business development and liaison activities with private, state/local government, transportation and related industry clientele nationwide. As such, he works with existing and prospective clients to develop geospatial methodologies that will deliver needed mapping and GIS information in a timely manner.

During the execution phase of a project, Jeff serves as the client's advocate within Quantum Spatial. He addresses all contractual issues that may arise during the project lifespan. He interfaces with the production manager to assure that all client requirements are met, and that all client concerns raised during the execution of the project are addressed in a timely manner. Additionally, Jeff directly supervises transportation sector business development corporate-wide.

Southeast Wisconsin Regional Planning Commission: Quantum Spatial has a solid history of providing mapping services to the Commission, including multiple iterations of new digital orthophotography in 1995, 2005, and 2007. The following projects were negotiated by Jeff and encompass approximately 2,800 square miles:

- 2013 Walworth County LiDAR Acquisition and Processing
- 2010 Racine County LiDAR Program – Acquire LiDAR and process contours
- 2010 Mequon City LiDAR 1-ft contours and 0.5-ft orthos
- 2010 Kenosha County LiDAR 1-ft contours and 0.25-ft orthos
- 2010 Digital Orthophoto Imagery Program Update – Kenosha, Milwaukee, Ozaukee, Racine, Walworth Washington, and Waukesha regional imaging
- 2007-2009 Washington County LiDAR acquisition and processing

Project Assignment
Project Manager

Education
BS, Geology and Geography; University of Wisconsin, 1974

Registration
ASPRS Certified Photogrammetrist #R1052

Professional Land Surveyor (Photogrammetry): North Carolina #L-4063

Professional Photogrammetry Surveyor: South Carolina #24050

Professional Surveyor Photogrammetrist: Virginia #0408000019

Years of Experience: 40

Years with Quantum Spatial: 40

Wisconsin Department of Transportation (WisDOT): Quantum Spatial has been providing professional mapping services to WisDOT through a single contract with multiple task orders. Recent task orders secured and negotiated by Jeff have included B/W imagery acquisition, film processing and editing, DTM creation, and planimetric mapping.

State of Illinois Statewide Imagery Program: Through a joint program with the Illinois DOT and the USGS, Quantum Spatial acquired 4-band DMC imagery for the entire state of Illinois. This project was completed in 2011 and consisted of 1-ft 4-band imagery for the state and an option for 6-inch resolutions in urban areas. Quantum Spatial managed over 11 planes and sensors collecting imagery data for this project.

St. Louis District, US Army Corps of Engineers, Champaign, Grundy, Kane, and McHenry Counties, Illinois: Quantum Spatial was subcontracted to acquire and process LiDAR digital elevation models for contour generation for an area encompassing approximately 2,562-square miles.

Jon Wittman, ATP, COM

Mr. Wittman directly manages flight coordination for all aerial acquisition projects including emergency response, digital imagery, LiDAR data acquisition, and imagery for photogrammetric and GIS mapping. Jon is also responsible for resources allocation of aircraft, sensors, and associated flight personnel. Jon monitors all aerial operations with real-time tools including aircraft feed tracking of all mobilized assets.

Southeast Wisconsin Regional Planning Commission: Quantum Spatial has a solid history of providing mapping services to the Commission, including multiple iterations of new digital orthophotography in 1995, 2005, and 2007. Jon managed all of the digital image acquisition for the following projects:

- 2013 Walworth County LiDAR Acquisition and Processing
- 2010 Racine County LiDAR Program – Acquire LiDAR and process contours
- 2010 Mequon City LiDAR 1-ft contours and 0.5-ft orthos
- 2010 Kenosha County LiDAR 1-ft contours and 0.25-ft orthos
- 2010 Digital Orthophoto Imagery Program Update – Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha regional imaging

Project Assignment

Flight Department Manager

Education

MBA, with emphasis on Project Management, Lakeland College, Sheboygan, WI, In Progress

BA, Specialized Administration, Lakeland College, 2006

AAS, Aeronautics, Gateway Technical College, 1991

Registration

Airline Transport Pilot
Commercial Pilot

Years of Experience: 21

Years with Quantum Spatial: 4

Illinois Department of Transportation (IDOT):

- PTB 162-031, P-30-009-12: Photogrammetry Contract Northern Area of Illinois
- D2266 Alton Connector Road LiDAR project
- D2302 FAP Route 742 High Accuracy LiDAR for Illinois Highway 2 via helicopter platform
- R5743 Mississippi River Bridge ground mobile and fixed wing LiDAR Project

State of Illinois Statewide Imagery Program: Through a joint program with the Illinois DOT and the USGS, Quantum Spatial acquired 4band DMC imagery for the entire state of Illinois. This project was completed in 2011 and consisted of 1-ft, 4-band imagery for the state and an option for 6-inch urban areas. Quantum Spatial (as AeroMetric) managed over 11 planes and sensors collecting imagery data for this project.

Illinois Department of Transportation: Under four separate Professional Transportation Bulletin (PTB) projects awarded to Quantum Spatial, 42 entire counties within the State of Illinois had LiDAR data acquired and processed based upon the Illinois Department of Transportation contract specifications. These areas jointly encompassed nearly 28,000 square miles of land within the State of Illinois.

Digital Orthophotography for the East Piedmont and Coastal Regions, State of North Carolina Floodplain Mapping Program: Quantum Spatial was the lead subcontractor for 27,530-square miles of acquisition and production of 0.5-ft color orthophotography for the eastern portion of North Carolina. During the course of acquisition, our team had as many as seven planes collecting imagery. Jon served as the Flight Operations Manager for the State of North Carolina Project including managing aircraft and seven DMC's collecting imagery for this project.

Mike Emanuel, GISP

Mike has 24 years of varied experience ranging from information system design, database design, application development, data management, and GIS development. Mike joined Quantum Spatial in 2011, bringing 23 years of experience including 10 years of experience in designing and implementing geospatial information systems (GIS, data management systems and 15 years of experience in project management. He serves as the IGS Project Manager, and provides program management for QA/QC, which includes:

- Supporting corporate QA initiatives
- Supporting the QA/QC Team Manager
- Providing internal auditing support
- Monitoring QA reporting and nonconformance response
- Ensuring the corporate QA process support client's needs

He specializes in providing "electronic" support to all aspects of a project from initial data modeling and database design through project closure and reporting. His experience also includes: needs assessments, implementation plans, design specifications, development and implementation of QA/QC procedures, data manipulation/evaluation, and system evaluation.

Project Assignment

QA/QC Manager

Education

MS, Information Systems, Robert Morris University, 2003

BS, Chemistry, Grove City College, 1988

Registration

Certified GIS Professional (GISP) #6846

Master's Certificate in Project Management, 2007, University of Pittsburgh, Katz Graduate School of Business, Pittsburgh, PA

Years of Experience: 25

Years with Quantum Spatial: 3

US Geological Survey – Geospatial Products and Services Contract, (GPSCII), various locations, Rolla, Missouri: Mike supported USGS in various Phase 1 Dam GIS projects. His responsibilities include oversight of GIT-dedicated IT Infrastructure, internal QA audits (including ISO internal auditing), proposal development, project management, staffing recommendation, and evaluation of software/hardware emerging technologies. Quantum Spatial (as AeroMetric) has completed over 130 total task orders for CSCI totaling more than $29.3 million. Under the past CSCII contract, Quantum Spatial executed over 62 task orders completing $16.5 million in digital and traditional imagery acquisition, LiDAR data acquisition and processing, and photogrammetric and GIS mapping.

Illinois Department of Transportation (IDOT): Mike was Director of QA/QC under the most recent Professional Transportation Bulletin (PTB) projects awarded to Quantum Spatial. Forty-five entire counties within the State of Illinois had LiDAR data acquired and processed based upon the Illinois Department of Transportation contract specifications. These areas jointly encompassed nearly 28,000-square miles of land within the State of Illinois.

Illinois State Toll Highway Authority: Mike served as Director of Quality Assurance/Quality Control for the following: RR-13-4119: Aerial Mapping Services upon Request Systemwide which currently consists of the Illinois Route 53 120 Project. Also, for RR-11-5642: Aerial Mapping Services upon Request Systemwide, Mike, as Director of QA/QC, provided consulting services to update the Tollway's existing current quality checklists to address current and newer technologies/workflows used to acquire digital imagery and LiDAR data. In addition, during the implementation of the contract, Quantum Spatial identified additional revisions that were incorporated in to the quality checklists to accommodate changing procedures that meet the Tollway's engineering expectations. All of these checklists were accepted and used as appropriate throughout the contract.

Rob Merry, RLS

As Geomatics Department Manager, Rob directs all activities related to tying collected geospatial data to the Earth geoid. He manages the design of control survey networks, and supervises the collection and post-processing (reduction) of field survey data. His department also generates all soft-copy aerotriangulation solutions for the Sheboygan production facility. In addition, Rob directs all planning, acquisition, and post-processing of LiDAR topographic data missions. His responsibilities also include personnel and budgetary management, direction of Quality Assurance/Quality Control (QA/QC) activities, and assistance in proposal and cost estimate generation.

He is also the resident expert on airborne Global Positioning System (GPS) and inertial measurement unit (IMU) technologies which Quantum Spatial utilized extensively for direct georeferencing of airborne vertical imagery during acquisition. Rob's extensive experience in LiDAR technology is well recognized in the profession and he has presented LiDAR Quality Assurance/Quality Control techniques, LiDAR deliverable expectations, and general LiDAR overviews to various governmental, transportation, and private clients.

Project Assignment

Geomatics Manager

Education
BS, Surveying, 1993

Registration
Registered Land Surveyor: Wisconsin #2412

Registered Land Surveyor: Michigan #47963

Years of Experience: 21

Years with Quantum Spatial: 21

Southeast Wisconsin Regional Planning Commission: Quantum Spatial has a solid history of providing mapping services to the Commission, including multiple iterations of new digital orthophotography in 1995, 2005, and 2007. Rob managed all the airborne and ground related control surveys on the following projects:

- 2013 Walworth County LiDAR Acquisition and Processing
- 2010 Racine County LiDAR Program – Acquire LiDAR and process contours
- 2010 Mequon City LiDAR 1-ft contours and 0.5-ft orthos
- 2010 Kenosha County LiDAR 1-ft contours and 0.25-ft orthos
- 2010 Digital Orthophoto Imagery Program Update – Kenosha, Milwaukee, Ozaukee, Racine, Walworth Washington, and Waukesha regional imaging
- 2007-2009 Washington County LiDAR acquisition and processing

Wisconsin Multi-County LiDAR Program: Rob managed the acquisition and processing for the 2010 Wisconsin Multi-County LiDAR Program. Quantum Spatial and Ayres Associates teamed together to manage this program to support potential acquisition of color, color IR, and black-and-white digital orthophotos at 3-inch, 6-inch, and 12-inch pixel resolution for all of Wisconsin in 2010. Acquisition of hyperspectral and multispectral imagery datasets were offered to all willing government organizations throughout Wisconsin. Additional services offered include photogrammetric mapping to produce digital terrain models, topographic mapping at 1-ft, 2-ft, and 4-ft contour intervals, and planimetric mapping. It is anticipated that Light Detection and Ranging (LiDAR) will be used for the production of terrain models and contour mapping.

Illinois Department of Transportation: Under four separate Professional Transportation Bulletin (PTB) projects awarded to Quantum Spatial, 42 entire counties within the State of Illinois had LiDAR data acquired and processed based upon the Illinois Department of Transportation contract specifications. These areas jointly encompassed nearly 28,000-square miles of land within the State of Illinois.

Mark Meade, PE, PLS, CP

Mark has managed an extensive number of projects and serves as a project advisor to almost all projects undertaken by the firm. He is current with the latest geospatial technology and takes an active role in all training for flight and ground crews, project planning, control placement, GPS reductions, and quality control. Mark authored Quantum Spatial's procedures manual and checklists used by the aerial and ground crews during airborne missions. Using his hands-on approach, he has conducted the calibration of the firm's airborne platforms, the setup of a test area for monitoring the accuracy of airborne platforms, and ground GPS monitoring for emergency or fast-track airborne projects.

Statewide Digital Orthophotography & LiDAR, Commonwealth of Kentucky: Quantum Spatial (as Photo Science) was tasked provide 4-band leaf-off, digital aerial imagery acquired using one of our DMCs. Additionally, Quantum Spatial has collected and processed over 7,000 square miles of airborne LiDAR as part of the program. Program deliverables include leaf-off natural color and near infrared digital orthophotos at 1-ft and 0.5-ft GSD, numerous digital elevation products derived from LiDAR and selective planimetric and topographic mapping updates. Quantum Spatial cloud based ortho QA tool, VOICE, has been customized and deployed to support collaborative QA review of the orthophotos across state, and local agencies. Mark serves as a technical advisor on this program.

Statewide Digital Orthophoto Program, State of North Carolina: Quantum Spatial has utilized a compliment of three DMCs for the 4-band image acquisition. Since 2012, Quantum Spatial (as Photo Science) has provided the entire project Team with imagery hosting integrated with a cloud-based ortho QC tool know as VOICE (Virtual Online Inspection, Checking, and Editing), which has been successfully used to support the concurrent, multi stakeholder quality review process of orthophoto deliverables.

Statewide Digital Orthophotography Mapping Update, State of New Jersey: Quantum Spatial (as Photo Science) was responsible for the acquisition of aerial photography, digital terrain models (DTM), and orthophotography (natural color and color infrared imagery at 1-ft GSD) for the State of New Jersey. The program involved the production of statewide color infrared digital orthophotography at the design scale of 1"=200' with a ground pixel resolution of 1-ft for approximately 8,000-square miles. Mark served as technical manager on this project.

North East LiDAR Program, US Geological Survey: Quantum Spatial (as Photo Science) collected and processed LiDAR data of a coastal zone spanning six North Eastern states, including Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, and New York. This multi-task order approach by USGS and participating federal, state and local agencies resulted in LiDAR acquisition and processing of over 8,000-square miles including enhanced vertical accuracies, post spacing and tide-coordinated acquisition of selective areas.

Project Assignment

Oblique Manager

Education

MBA, Business Administration; University of Kentucky, 1987

BS, Civil Engineering; University of Kentucky, 1983

Registration

ASPRS Certified Photogrammetrist #R1050

Professional Engineer: Kentucky #15056

Professional Engineer: Nebraska #E14837

Professional Engineer: West Virginia #10505

Professional Land Surveyor: Georgia #2750

Professional Land Surveyor: Kentucky #2970

Professional Land Surveyor: West Virginia #1139

Geodetic Surveyor: South Carolina #24536

Photogrammetric Surveyor: South Carolina #24536

Years of Experience: 33

Years with Quantum Spatial: 33

Chris Schnell, CP

Project Assignment

Ortho Manager

Education

BS, Geography and Biology, University of Wisconsin, 1994

BS, Computer Science, Lakeland College, 2001

Registration

ASPRS Certified Photogrammetrist #R1562

Years of Experience: 17

Years with Quantum Spatial: 17

Chris oversees the scanning, digital orthophoto generation, imaging, image finishing, and graphics areas. In his role, he is in charge of departmental staff supervision, project management, scheduling, client contact, reporting, yearly budgets and software maintenance. Chris has managed all Commission orthophoto and map editing projects for the past 17 years.

He has extensive experience managing the integration of LiDAR terrain data and imagery to form digital orthophotos and image mosaics. Chris joined Quantum Spatial in 1997 and was promoted to his current post in 2006. He has managed all Illinois DOT CADD graphic and terrain projects.

Wisconsin Statewide Digital Orthophoto and Multi-County LiDAR Program: Chris was the image and terrain processing manager for the 2010 program referenced above. Quantum Spatial and Ayres Associates teamed together to manage this program to support potential acquisition of color, color IR, and black and white digital orthophotos at 3-inch, 6-inch, and 12-inch pixel resolution for all of Wisconsin in 2010. Acquisition of hyperspectral and multispectral imagery datasets were offered to all willing government organizations throughout Wisconsin. Additional services offered included photogrammetric mapping to produce digital terrain models, topographic mapping at 1-ft, 2-ft, and 4-ft contour intervals, and planimetric mapping. It is anticipated that Light Detection and Ranging (LiDAR) will be used for the production of terrain models and contour mapping.

Illinois Department of Transportation: Under four separate Professional Transportation Bulletin (PTB) projects awarded to Quantum Spatial, forty-two entire counties within the State of Illinois had LiDAR data acquired and processed based upon the Illinois Department of Transportation contract specifications. These areas jointly encompassed nearly 28,000 square miles of land within the State of Illinois.

State of Illinois Statewide Imagery Program: Through a joint program with the Illinois DOT and the USGS, Quantum Spatial acquired 4-band DMC imagery for the entire state of Illinois. This project was completed in 2011 and consisted of 1-ft resolution, 4-band imagery for the state and an option for 6-inch buy-up areas. Quantum Spatial managed over 11 planes and sensors collecting imagery data for this project.

Illinois State Toll Highway Authority:

- RR-11-5642: Aerial Mapping Services Upon Request – Systemwide
- RR-05-5478: LiDAR Derived I-355 As built Survey
- RR-04-5478: Design scale aerial photo acquisition along I-294 at I-57 interchange project.

US Geological Survey–Geospatial Products and Services Contract, (GPSCII): Since 1997, Chris was the image and terrain processing manager for all contracts with USGS. Chris is directly managing three consecutive geospatial data production contracts with USGS and completing over 130 total task orders totaling more than $29,285,000. Under the current GPSC contract, Chris is also managing the execution of over 80 task orders, completing $20.5 million in digital and traditional imagery, LiDAR data acquisition and processing, and photogrammetric and GIS mapping for the USGS and external state and local government customers.

Dave Irwin

Dave joined Quantum Spatial in the spring of 2006. He is the Geospatial Department Manager for Quantum Spatial's Sheboygan, WI, production facility. In this role, he is responsible for production scheduling, quality training of personnel, and managing two shifts of employees performing stereo compilation services. He has also served as the lead person in Quantum Spatial's LiDAR Department, where he managed projects from post-calibration through delivery using TerraScan, TerraModeler, and MicroStation software.

His background includes over 7 years as an aerial photography pilot, experience as an aerial photographer, and 6 years as a stereo compiler. He has over 2,500 flight hours, including 9 years and 1,150 hours as a Naval Aviator. He has performed stereo image compilation of topographic maps using Kern PG-2, Zeiss P-33, and softcopy workstations with Bentley MicroStation and CADMap.

Project Assignment

Geospatial Manager

Education

BMSE, Valparaiso University, 1986

US Naval Aviation Flight Training, 1987

Jet Engine Mishap Investigation, Sheppard Air Force Base, 1992

Human Factors in Aviation Safety, University of Southern California, 1992

Aircraft Accident Investigation, University of Southern California, 1993

Years of Experience: 16

Years with Quantum Spatial: 8

Southeast Wisconsin Regional Planning Commission: Quantum Spatial has a solid history of providing mapping services to The Commission, including multiple iterations of new digital orthophotography in 1995, 2005, and 2007. The Geospatial production was part of the following projects were prepared by Dave:

- 2013 Walworth County LiDAR Acquisition and Processing
- 2010 Racine County LiDAR Program – Acquire LiDAR and process contours
- 2010 Mequon City LiDAR 1-ft contours and 0.5-ft orthos
- 2010 Kenosha County LiDAR 1-ft contours and 0.25-ft orthos
- 2010 Digital Orthophoto Imagery Program Update – Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha regional imaging
- 2007-2009 Washington County LiDAR acquisition and processing

Digital Orthophotography for the East Piedmont and Coastal Regions, State of North Carolina Floodplain Mapping Program: The State of North Carolina required new digital aerial orthophoto as part of its program to maintain, update, and issue flood hazard data and produce and disseminate updated flood maps. Quantum Spatial was the lead subcontractor for 27,530-square miles of acquisition and production of 0.5-ft color orthophotography for the eastern portion of North Carolina.

Illinois Department of Transportation: Under four separate Professional Transportation Bulletin (PTB) projects awarded to Quantum Spatial, 42 entire counties within the State of Illinois had LiDAR data acquired and processed based upon the Illinois Department of Transportation contract specifications. These areas jointly encompassed nearly 28,000-square miles of land within the State of Illinois.

3. CLIENT REFERENCES

The Quantum Spatial team has the experience and capability to provide the services required of the 2015 Orthophotography Project for the Commission. For each project we undertake, we evaluate the required output dataset requirements, sources of data available, and accuracies required; we always recommend the best, most cost effective approach toward each project. This approach and dedication to providing quality geospatial services is exemplified in the following project references. As demonstrated by our desire to exceed expectation, we have offered what we consider the best solution for Commission. Figure 4 demonstrates our firm's experience related to the projects presented on the pages following the table. These are only a few of the many projects we have undertaken performing similar services requested by Commission. Should you request additional project references, we would be happy to provide those to you.

Figure 4: Client References

No.	Project Name	Client	Contact	Aerial Photography	Orthophotography	LiDAR Collection	Control Surveys
1	Digital Orthophoto Programs & Related Geospatial Mapping Services	Southeastern Wisconsin Regional Planning Commission	John McDougall 262-547-6721 jmcdougall@sewrpc.org	●	●	●	●
2	Statewide Imagery Program	East Central Wisconsin Planning Commission	Trish Nau 920-751-4770 tnau@eastcentralrpc.org	●	●	●	●
3	Statewide Imagery Program	Illinois Department of Transportation	Amy Eller 217-782-4748 amy.eller@illinois.gov	●	●	●	●
4	Digital Orthophoto & LiDAR Mapping Services	Kentucky Commonwealth Office of Technology	Thomas Rossman (502) 564-6412 thomas.rossman@ky.gov	●	●	●	●
5	Multiple Statewide Digital Orthophoto & LiDAR Mapping Services	U.S. Geological Survey	Tim Saultz (573) 308-3757 tsaultz@usgs.gov	●	●	●	●

PROJECT 1 – DIGITAL ORTHOPHOTO PROGRAMS & RELATED GEOSPATIAL MAPPING SERVICES

Client
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
Waukesha, WI 53188

John McDougall, GIS Manager
262-547-6721
jmcdougall@sewrpc.org

Period of Performance
1995–2011

Key Professional Services

- Flight planning and image acquisition
- LiDAR topographic data acquisition
- LiDARgrammetry and conventional DTM generation
- Image orthorectification and mosaicking
- 0.25-ft, 0.5-ft, and 1-ft, GSD color aerial photography acquisition and digital orthophotography
- GPS network 3D transformation

Quantum Spatial (as AeroMetric) has provided professional geospatial mapping services for Southeastern Wisconsin Regional Planning Commission for more than 34 years. Quantum Spatial has successfully completed hundreds of projects for the Commission and its member jurisdictions since the early 1980.

The Highway Safety Improvement Program's 133 Urban Areas necessitates that frequent acquisitions are needed to keep high resolution imagery updated every 2-4 years in these areas to certain standards.

Milwaukee, Washington, and Waukesha Counties: One of the assignments completed was the higher resolution regional digital orthophoto program to acquire data to fulfill base layer imagery requirements for local, state, and federal government use. All counties in the region were provided with orthos for their county and adjacent counties to support effective collaboration between government entities. Quantum Spatial acquired imagery in spring 2010 for the three county (1,414 square mile) area. Color digital orthophoto image files were prepared at 6-inch pixel resolution to meet NGA Urban Area Orthorectified Imagery Specifications.

Kenosha County LiDAR and 3-inch Orthophotography: During spring 2010, Quantum Spatial acquired high resolution imagery utilizing AB/GPS for Kenosha County; a 328 square mile area. New LiDAR data complete with 100 GPS checkpoint validations (20 per each of the 5 FEMA Ground Cover Categories) was also acquired for the same area. LiDAR data was processed to automated bare earth pint cloud status to support the orthorectification process. Special flight lines were flown over the City of Kenosha to support the Urban Area 133 Cities requirements for minimal building lean perspective. Softcopy aerotriangulation was completed for all imagery and color digital orthophoto image files were prepared at a 3-inch pixel resolution for 386 5,000-ft x 5000-ft mosaic tiles.

Figure 5: The Marcus Amphitheatre, Milwaukee SummerFest Grounds; 1-ft resolution

City of Mequon LiDAR and 6-inch Orthophotography: During spring 2010, Quantum Spatial acquired high resolution imagery utilizing AB/GPS for a predefined 48 square mile area in the city of Mequon. New LiDAR data complete with 100 GPS checkpoint validations (20 per each of the 5 FEMA Ground Cover Categories) was also acquired for the same area. LiDAR data was processed to automated bare-earth point cloud status and 1-ft contours were generated. Softcopy aerotriangulation was completed for all imagery and color digital orthophoto image files were prepared at a 6-inch pixel resolution for 20 10,000-ft x 10,000-ft mosaic tiles.

Regional Digital Orthophoto Program Update – 2007: Quantum Spatial's utilized its premiere Z/I DMC for five counties (over 2,000 square miles) within the Commission in 2007 flying at 10,000-ft above mean terrain (AMT). This altitude was sufficient to generate a 1-ft ground sample distance (GSD) resolution for the entire area at 1"=200' mapping standards. A new digital elevation model (DEM) was generated from the new imagery in areas of recent change. The small areas of DEM change were fenced into the 2005 DEM to yield an up-to-date DEM. The composite DEM was utilized along with control recovered by Quantum Spatial surveyors to generate color digital orthophotography on the Commission's 10,000-ft x 10,000-ft tile scheme. The digital orthophotos were delivered in GeoTIFF format on external hard drives with FGDC-compliant metadata.

Regional Digital Orthophoto Program – 2005: Digital imagery was completed for six counties within the Commission area. Five counties were imaged at 10,000-ft AMT for a 12-inch GSD and one county was imaged at 5,000 AMT for a 6-inch GSD resolution. The six-county project area contained approximately 2,800 square miles. Color digital orthophotography was produced and delivered on a GeoTIFF format. The imagery was combined with control data and a DEM generated from the imagery to generate digital orthophotos at a 1-ft GSD for five of the counties, at a scale of 1"=200' on a 10,000-ft x 10,000-ft tile schema. Approximately 2,500 individual tiles were generated at this GSD. The lower-altitude imagery was utilized in combination with control and the DEM to generate 6-inch GSD digital orthophotos for the remaining county. This area was imaged for use in viewing at 1"=100', based upon a 5,000-ft x 5,000-ft tile scheme. A total of 745 tiles were generated at this resolution. The entire project was flown during April 2005 and delivered by December 31, 2005.

Milwaukee County (MCAMLIS) – 2005: Quantum Spatial was contracted to produce professional mapping services for 245 square miles of Milwaukee County. These services included the disciplines of aerial photography, airborne GPS, GPS geodetic control, digital vector mapping, digital terrain modeling (DTM), and color digital orthophoto mapping. Aerial photography was completed at 1"=500' with a precision mapping camera using color aerial film. The project required 24 flight lines and 800 exposures for photogrammetric coverage. Digital vector mapping was prepared at 1"=100' with 2-ft contours based upon a 10,000-ft x 10,000-ft tile schema. Contours were developed from photogrammetrically obtained DTM involving mass points and breaklines. The project generated approximately 90 tiles of mapping in MicroStation 3D DGN format. A unique file structure was employed, allowing data elements to be selectively retrieved, manipulated and displayed singly or in combination with other data elements. Color digital orthophotos in GeoTIFF format were completed at 1"=100' with a six-inch pixel resolution on a 5,000-ft x 5,000-ft tile schema as subsets of the tile schema for the digital vector mapping.

Regional Digital Orthophoto Program – 1995: Quantum Spatial served as prime contractor to the Commission in 1995 to generate the first-ever digital orthophoto series for the seven-county consortium and its member jurisdictions. Approximately 1,400 frames of 1"=1,667' scale black-and-white panchromatic photography were acquired. Quantum Spatial's subcontractor collected GPS ground control points at 24 perimeter PLS section corners to serve as control. Each contractor generated an analytical aerotriangulation solution for its portion of the project area. A DEM was generated for each portion of the project area from stereo compilation. Digital orthophotos with a 2-ft GSD were generated and tiled to 706 PLS quarter sections. Hard copy reproducible mylar plots were generated at 1"=400' scale. All digital orthophotos were delivered in TIF format with Esri World files on CD-ROM.

PROJECT 2 – STATEWIDE IMAGERY PROGRAM

Client
East Central Wisconsin Planning Commission
400 Ahnaip Street, Suite 100
Menasha, WI 54952

Trish Nau
920-751-4770
tnau@eastcentralrpc.org

Period of Performance
2009–2011

Key Professional Services

- Flight planning and image acquisition
- 3-inch, 6-inch and 1-ft GSD color, color IR, and black-and-white orthophoto generation and aerial photography
- DTM produced with 1-ft, 2-ft, and 4-ft contours

Digital orthophotography is used at the state level for emergency planning and response, government decision-making, and land use policy development. The Wisconsin Regional Orthophotography Consortium (WROC) is a multi-entity group led by several Regional Planning Commissions. WROC's goal was to allow multiple participants to acquire updated digital orthophoto and elevation data at a time when grants were available to do this. All 72 Wisconsin counties participated in this effort as well as several individual municipalities.

Quantum Spatial (as AeroMetric) and Ayres Associates teamed together to manage this program to support potential acquisition of color, color IR, and black-and-white digital orthophoto at 3-inch, 6-inch, and 12-inch pixel resolution for all of Wisconsin in 2010. Acquisition of hyperspectral and multispectral imagery datasets were offered to all willing government organizations throughout Wisconsin. Additional services offered include photogrammetric mapping to produce digital terrain models, topographic mapping at 1-ft, 2-ft, and 4-ft contour intervals, and planimetric mapping. It is anticipated that Light Detection and Ranging (LiDAR) will be used for the production of terrain models and contour mapping. This project was sponsored by the Wisconsin Regional Planning Commission. WROC's goal was to allow as many participants as possible to obtain mapping. In order to satisfy the varying needs of each government agency, imagery was offered at multiple pixel resolutions with buy-up options.

Figure 6: East Central Wisconsin Planning Commission

The size of the project continued to grow right up to the flying season. The answer was to over plan by securing the commitment of acquisition and data processing partners early and prepare for the possibility that the entire state (approximately 65,498-square miles) would be mapped.

Photogrammetric control surveys were required to augment the basic Airborne Global Positioning surveys. These supplemental surveys were completed in part by the mapping team, and by the various counties and municipalities. Thus the timing for the receipt of the field surveys varied greatly. The actual orthophoto processing could not begin until the control survey data was received.

Further affecting the project task scheduling were the actual dates the imagery was collected. Since the entire State was involved in imagery collection, the time frame for the collection spanned the spring of 2010 leaf-off flight season. The processing efforts were scheduled to begin as each area was collected, followed by the supplemental surveying and terrain surface development. Therefore individual project deliverable schedules were formulated upon the dates in which the survey control was provided, and the estimated man-hours associated with each task.

It was necessary to depend on an extensive team of area leaders to focus on being attentive to the needs of each participant. After negotiations took place, the assignment was given to the respective project manager depending on services ordered. Each project manager was the point of contact in charge of all project management duties for their client, including meeting planning, facilitation, note preparation, developing production assignment documentation, production scheduling, status reporting on flight mission completion, production delivery status, issue resolution, and invoice and payment tracking.

PROJECT 3 – STATEWIDE MAPPING SERVICES

Client
Illinois Department of Transportation
2300 S. Dirksen Parkway, Room 005
Springfield, IL 62764

Amy Eller
217-782-4748
amy.eller@illinois.gov

Period of Performance
2011–2013

Key Professional Services

- Flight planning and image acquisition
- 6-inch and 1-ft GSD color digital imagery acquisition and orthophotography generation

Quantum Spatial (as AeroMetric) has provided precision engineering-scale mapping services to the Illinois Department of Transportation (IDOT) for over 35 years.

During 2011 Quantum Spatial acquired raw digital imagery for the entire State of Illinois except the seven counties in the northeastern metro area (Chicago area). Under a program for the Illinois Department of Transportation (IDOT), and contractually administrated by the USGS, Quantum Spatial was the prime contractor to acquire and process 4-band imagery. The final ortho image processing was completed in 2013, and consisted of 1-ft 4-band imagery for 58,560-square miles of the state, including 1,772-square miles, 6-inch pixel resolution areas.

Quantum Spatial managed the deployment of 11 aircraft and sensors in 2011 to collect 53,849 exposures for this project. Quantum Spatial coordinated imagery acquisition by priority blocks to follow snow regression and flood-free conditions. Project aerial imagery and final digital orthophoto imagery was completed according to USGS specifications. Quantum Spatial provided:

- Statewide, leaf-off imagery and orthophotos at 1-ft resolution with county up-grades to 6-inch resolution
- Coordination of Quantum Spatial aircraft and digital image sensors. .

Figure 7: Imagery from the Illinois statewide mapping services program

PROJECT 4 – DIGITAL ORTHOPHOTO & LIDAR

Quantum Spatial (as Photo Science) has been tasked by the Kentucky Commonwealth Office of Technology to provide a common statewide digital orthophoto basemap, including current color leaf-off aerial photography and elevation data (LiDAR) for the entire state of Kentucky. The project includes higher resolution and base resolution sub area, supported by stakeholder funding. Program deliverables include, but are not limited to: leaf-off, 4-band digital orthophotos at 1-ft and 6-inch resolutions, along with LiDAR digital elevation products. Oblique imagery collection and processing was also performed under this contract in Campbell and Kenton Counties.

In 2013, Quantum Spatial collected 3,270 square miles of LiDAR, 2,637 square miles of 1-ft imagery and 323 square miles 6-inch orthophotos. Feature updating was also undertaken in the higher resolution area. Additionally, Quantum Spatial performed 323 square miles of planimetric mapping for Paducah/McCracken County Kentucky, which was 1"=100' scale. This was mostly an update of original mapping completed in 2007, but contained areas of new mapping. Quantum Spatial also did 323 square miles of 6-inch orthos in the County as well.

In 2012, Quantum Spatial collected a total of 3,784 square miles of LiDAR imagery utilizing both Optech and Leica sensors to deliver raster DEM, and classified LAS v1.3 point cloud. The dataset was delivered to USGS specifications. Additionally, a total of 5,785 square miles of 1-ft imagery and 973 square miles 6-inch imagery were collected and processed.

All mapping products are being delivered in Kentucky Single Zone State Plane coordinates NAD83* geometric datum and NAVD88 vertical datum. Quantum Spatial provides a certification of product accuracy in terms of ASPRS Class Accuracy Standards for all furnished products. Vertical color aerial digital photography is captured for the 'higher resolution' sub-area at a scale sufficient for producing 1"=100' stereo photogrammetric mapping meeting ASPRS Class 1 accuracy standards for large scale maps and for production of color digital orthophotography at a resolution of 0.5-ft.

Vertical color aerial digital photography is captured for the base resolution sub-area at a scale sufficient for producing 1"=200' stereo photogrammetric mapping meeting ASPRS Class 1 accuracy standards for large scale maps and for production of color digital orthophotography at a resolution of 1-ft. Quantum Spatial is utilizing our DMCs to acquire natural color (RGB) and additionally the near infrared (NIR) band.

Noteworthy, the State has deployed Quantum Spatial's VOICE application as a means of providing a cloud-based stakeholder digital orthophoto quality control applications. Quantum Spatial's FOCUS application is also being utilized as a LiDAR quality "self-certification" tool.

Client
Kentucky Commonwealth Office of Technology
100 Fair Oaks Lane
Frankfort, KY 40601

Thomas Rossman
(502) 564-6412
thomas.rossman@ky.gov

Period of Performance
2011—2014

Key Professional Services

- Flight planning and image acquisition
- LiDAR topographic data acquisition
- LiDARgrammetry and conventional DTM generation
- Image orthorectification and mosaicking
- 6-inch and 1-ft GSD color digital aerial imagery acquisition and orthophoto generation

Figure 8: Kentucky Statewide Ortho Example

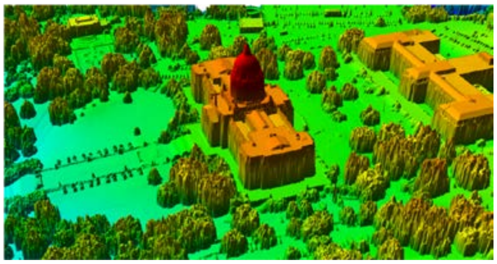


Figure 9: Kentucky Statewide LiDAR Example

PROJECT 5 – MULTIPLE STATEWIDE DIGITAL ORTHOPHOTOPHOTOS & LIDAR

Client
U.S. Geological Survey
Denver Federal Center
Denver, CO 80225

Tim Saultz
(573) 308-3757
tsaultz@usgs.gov

Period of Performance
2010–2013

Key Professional Services

- Flight planning and image acquisition
- 6-inch and 1-ft GSD color digital orthophoto generation and aerial photography

Quantum Spatial (as Aero-Metric and Photo Science) has been providing professional photogrammetric mapping and GIS services support to the US Geological Survey since 1999. These broad-based contracts have accelerated the USGS' ability to meet the geospatial needs of their customers, namely other state and local governments, federal agencies, and the private sector. Quantum Spatial was been tasked with more than a dozen large LiDAR collection and orthophoto processing projects throughout the US including:

Connecticut: In 2011, Quantum Spatial collected a high-resolution, 4-band multispectral, digital orthophoto imagery dataset covering more than 5,100 square miles — entire state of Connecticut. This project consisted of two components aerial imagery acquisition, and digital orthophoto production. Final task order deliverables included: 4-band (RGB, NIR) digital orthophotos in GeoTIFF format for 1-ft GSD.

New Hampshire: In 2010, over 19,000 frames of multi-resolution, multi-spectral imagery were captured with ABGPS/IMU by Quantum Spatial using a compliment of three DMCs to support the production of both statewide 4-band digital orthophotos at a GSD resolution of 30cm and higher resolution 15cm (6-inch) GSD digital orthophotos, of numerous participating towns across the State. Additionally, Quantum Spatial collected airborne topographic LiDAR data of the same participating towns to produce a higher accuracy DEM capable of supporting ASPRS Class 1 horizontal accuracies at a design scale of 1"=1,200' for the 15cm (6-inch) GSD orthophotography.


Figure 10: New Hampshire Ortho Example

Rhode Island: In 2011, over 6,000 frames of multi-resolution, multi-spectral imagery were captured with ABGPS/IMU by Quantum Spatial using its compliment of three DMCs to support the production of both statewide 4-band digital orthophotos at a GSD resolution of 15cm (6-inch). Additionally, Quantum Spatial collected airborne topographic LiDAR data of the State as part of the North East LiDAR project which was utilized to produce a higher accuracy DEM capable of supporting the required 0.76m horizontal accuracy at the 95% confidence level based on NSSDA testing guidelines. Quantum Spatial updated impervious layer and the land use/land cover dataset for Rhode Island with a focus on urban land use. The project uses an innovative approach that leverages both photo-interpretation, remote sensing and GIS analyses, which allows the creation of a consistent statewide dataset. The non-urban areas are being mapped to the Rhode Island Ecological Communities Classification.

NE LiDAR: Quantum Spatial was awarded multiple task orders to collect and process LiDAR data of a coastal zone spanning six North Eastern states including Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, and New York. This resulted in LiDAR acquisition and processing of over 8,000 square miles and included enhanced vertical accuracies, post spacing and tide coordinated acquisition of selective areas. Project deliverables included: all return point data in .LAS format, hydro-flattened classified points, bare earth data in .LAS format, DEM bare earth, FGDC compliant metadata, project-level data in XML format adhering the USGS LiDAR Base Specifications.

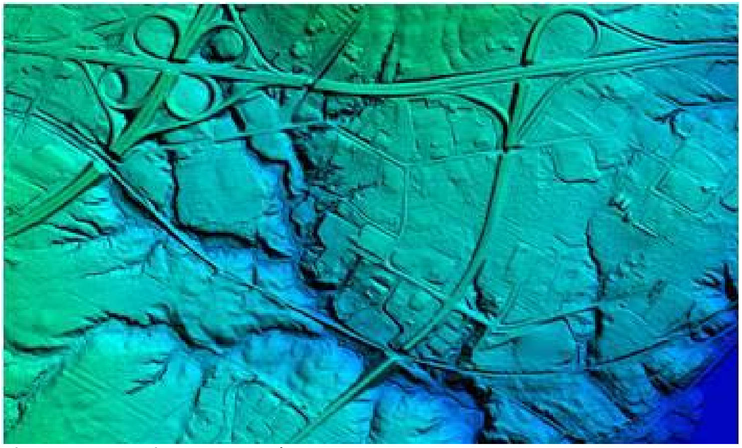


Figure 11: NE LiDAR Example

1. DIGITAL AERIAL IMAGERY ACQUISITION

Figure 12: Digital Aerial Imagery Acquisition
Quantum Spatial will utilize our ultra-large-format, frame-based UltraCam Eagle for the image acquisition.
Quantum Spatial's plan of operations includes a *same generation* (UltraCam Eagle 80mm model) methodology for the acquisition phase. This approach optimizes back-end post-processing, orthophoto production efficiencies, and workflow standardization.
The Quantum Spatial Team has proven experience in 0.25-ft pixel or better image acquisition for tens of thousands of square miles including recent projects for the State of Wisconsin, Illinois, North Carolina; State of New Hampshire; State of Rhode Island, and Washington, DC.
Quantum Spatial's imagery processing is based on a centralized post-processing solution at our Lexington, KY pixel factory to maximize processing efficiencies, standardization, and quality.
Quantum Spatial team members have more than 80 years of flight operation planning and executive expertise.

As outlined in Figure 12, the Quantum Spatial Team has the technical understanding of the mission planning, resource allocation experience, and task scheduling capacity necessary for a successful, digitally based imagery acquisition campaign to take place in the Spring of 2015.

*Quantum Spatial will use our ultra-large-format, frame-*based Microsoft UltraCam Eagle 80mm digital cameras to support the 2015 Orthophotography Project. Factory camera calibration certificates for the camera are available in Appendix A of this response. Quantum Spatial Team members have more than 80 years of experience in photogrammetric flight operation planning and execution. Our flight acquisition experience ranges from large-scale engineering projects for our Department of Transportation clients to complex large-area programs such as recent multi-resolution, multi-band statewide projects for the States of Wisconsin, Illinois of North Carolina, New Hampshire, Connecticut, Rhode Island, Kentucky, Pennsylvania, and New Jersey. These attest to our ability to successfully complete photogrammetric missions, confronted with environments of extreme terrain variations, spring weather climatic conditions, and compressed schedule requirements.

2. DIGITAL AERIAL CAMERA

Quantum Spatial proposes to deploy the Microsoft UltraCam Eagle digital camera technology interfaced with ABGPS/IMU to enable simultaneous acquisition of multi-spectral imagery for the Commission's 2015 Aerial Photography and LiDAR Project. Our Eagle digital image sensors are being proposed for the 0.25-ft, 0.5-ft and 1-ft GSD orthophoto project as they are the same generation camera platform/sensor configuration insuring imagery and workflow compatibility. Additionally, any higher resolution options will be acquired using the same flight parameters (with the exception of flying height adjustments for improved accuracy and resolution or true orthophoto areas).

The Eagle camera system is also equipped with forward motion compensation (FMC). This capability is similar in nature to the image blur removal concepts used in film cameras. The only difference, however, is that the Eagle camera is without the limitation and potential failure modes associated with moving parts in film cameras.

The Eagle digital sensors are very similar in nature to a film-based methodology in that they are best capable of supporting large-scale mapping applications. Moreover, due to the design of the Eagles, it outperforms older generation, smaller frame and pushbroom digital camera systems at the higher pixel resolutions required for this project. Considering the technical capabilities of the digital sensor and the GSD pixel resolutions required as deliverables, Quantum Spatial is proposing the use of our Eagle digital sensors as our premier standard for digital image acquisition in conjunction with this program.

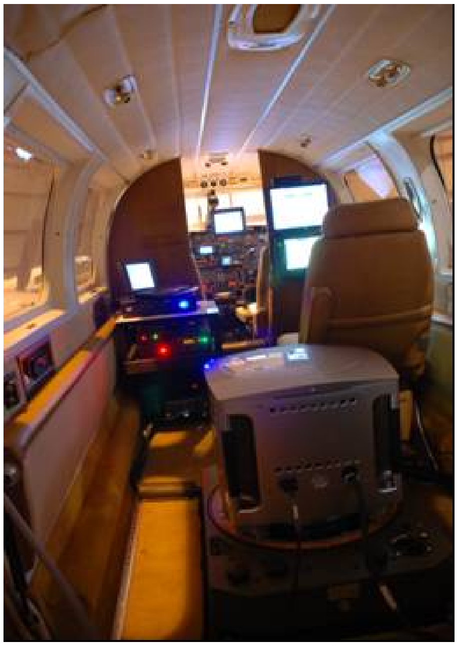


Figure 13: UltraCam Eagle in a twin-engine aircraft

The UltraCam Eagle is a large-format digital aerial camera manufactured by the Microsoft Corporation. The system is gyro-stabilized and simultaneously collects panchromatic and multispectral (RGB & NIR) imagery. The Quantum Spatial Team utilizes Leica PAV30© Gyro-Stabilized camera mounts with the Eagle system. Camera drift inputs to the PAV30 mount are sent by the X-Track© Flight Management system in conjunction with accurate measurements supplied by the Airborne Global Positioning System Applanix POS-AV© with IMU.

Panchromatic lenses collect high resolution imagery by illuminating nine CCD (charged coupled device) arrays, writing nine raw image files. RGB and NIR lenses collect lower resolution imagery, written as four individual raw image files. Level 2 images are created by stitching together raw image data from the nine panchromatic CCDs and ultimately combined with the multispectral image data to yield Level 3 pan-sharpened tiffs.

The UltraCam Eagle installed in one of our twin-engine aircraft (Figure 13) offers the ultimate in reliability and efficiency for the collection of digital aerial photography. With a PAN image footprint of more than 20,000 pixels across the flight strip, and an image capture rate of 3.7 gigabits per second, it performs well beyond traditional large-format digital cameras. The solid-state storage system stores 3,800 superior-quality images and can be exchanged in flight to meet any storage need. *Utilizing our UltraCam Eagles, the Quantum Spatial Team will capture more data in less time, and complete the Commission 2015 Orthophotography in fewer flight lines and with greater efficiency than ever before.* Camera Specification Highlights:

- Panchromatic image size: 20,010 x 13,080 pixels
- Input data quantity per image: 842 megabytes, 260 megapixels
- Lens system 1: 80 mm PAN and 27 mm RGBNIR
- Maximum frame rate <1.8 seconds per frame
- CCD image dynamic: 14-bit; workflow dynamic: 16 bit
- Camera Computer and Data Storage Subsystem (CEDE)
- Solid-state disc pack, storage of mirror images of the data on the data unit
- Unlimited with use of multiple data units with approximately 3.3 terabytes (3,800 images) per unit

3. ABGPS/IMU

The Quantum Spatial Team will deploy airborne GPS (ABGPS) and inertial measurement unit (IMU) technologies during the aerial imagery acquisition phases as part of the orthophoto control process. Quantum Spatial Team members have more than 15 years of experience in ABGPS control operations including direct georeferencing. Team members currently maintain Applanix POS Sensors installed with all Eagle precision digital framing cameras.

Direct georeferencing 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. To that end, we utilize the latest Applanix POS-Pac©

Air software package. This software features the advanced Applanix SmartBase© software and Applanix IN-Fusion© technology for increased productivity, accuracy and robustness without the limitations of numerous ground stations.

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 GPS. Stringent requirements will be maintained by Team members for the GPS satellite configuration. Flight GPS systems will collect data at a 10º elevation mask with actual satellite data used at a 12–15º mask during post-processing. With collection times planned to include at least six satellites in view, flight crews will operate under a rigorous specification of the PDOP not exceeding 4.0 for 90% of the time and in no instance greater than five.

Flight restrictions from the GPS satellite configurations are analyzed each morning prior to flight with a current satellite ephemeris. If changes have occurred (beyond the expected normal daily shift of the satellite constellation), such as newly listed unhealthy satellites or other facts, and these changes will be incorporated into that day’s flying. Additionally, PDOP is monitored during flight and if an unusual spike in encountered it is dealt with at the time by curtailing acquisition until the spike has passed. Camera perspective centers will be accurate to within 10cm with the GPS antenna position accurate to within 5cm. The final ABGPS/IMU solution will be delivered to Commission for review and certification before the Quantum Spatial Team commences with aerotriangulation.

4. FLIGHT PLANNING

Figure 14: Quantum Spatial Turbo Commander

Using our compliment of twin-engine aircraft such as the Turbo Commanders (see Figure 14), the Quantum Spatial Team will acquire digital aerial imagery during the collection window generally beginning on or around Feb 15, 2015 to Apr 15, 2015, complying with the “Spring” specifications outlined in the RFP and includes:

Conditions during Acquisition

During the project flight window, the Team’s aircraft will conduct operations out of local general aviation airports in and around the project area. Imagery will be acquired when the sky is clear; the ground is free from snow, haze, smoke, dust, and cloud shadows; and deciduous trees are sufficiently barren to permit the intended uses of the imagery. Spectral reflectance from water will be minimized and will not obscure shoreline features. The solar angle will be 30º or more above the horizon at the time of exposure. Reasonable efforts to conduct urban area acquisitions will be made at a minimum 40º sun angle.

Sun Angle Checker

To ensure all flown frames fit within the specified solar angle restrictions, Quantum Spatial has developed a web-based application used both in the planning phase and in the field by pilots and camera operators. Rather than rely on a single time range for the entire project, Quantum Spatial looks at every planned photo center to determine the specific acceptable start and end time for each individual frame. These frame-level results are then combined into a single time range for each flight line — by taking the latest frame’s start time and the earliest frame’s end time — to give a mathematically perfect time range that will ensure an ideal solar angle for every flown frame in the project. These results are available to pilots and camera operators in the field through the use of their smart phones and the website. The web page always defaults to the current day’s ranges, but past or future days can be accessed using the ‘Yesterday’, ‘Tomorrow’, ‘Last Week’ and ‘Next Week’ links at the top of the page. A PDF (see Figure 15) can also be generated using the links at the bottom of the page. These PDFs are generated and printed for all planned flight weeks to ensure this information is available even in those rare occasions where cell phone connectivity fails.

Re-Flights

Quantum Spatial will correct at no additional fee, aerial imagery that does not meet RFP specifications. All re-flights will be centered on the plotted flight lines and will be taken with the same digital sensor system. If Quantum Spatial fails to acquire the entire area in a single flying season, follow-up re-flights are required to complete full counties that were not initially fully completed. Quantum Spatial understands that partial county deliverables split between multiple acquisition seasons is not acceptable.

Forward Overlap

Quantum Spatial's planned forward overlap is 60% (±3% allowance for deviation) for all proposed 3,500-ft, 7000-ft and 14,000-ft AMT imagery.

Side Lap

Quantum Spatial's planned flight line side lap is 30% in general for all flight altitudes with specific planned exceptions in urban areas where building lean considerations are anticipated. Similar considerations were completed in conjunction with previous projects for the Commission.

FL	Length (miles)	Est. Time (220 knots)	Frames	Sun, 2/16	Mon, 2/17	Tue, 2/18	Wed, 2/19	Thu, 2/20	Fri, 2/21	Sat, 2/22
001	3.24	0:46	18	11:48 - 13:41	11:43 - 13:46	11:38 - 13:50	11:33 - 13:55	11:29 - 13:59	11:25 - 14:02	11:21 - 14:06
002	1.63	0:23	8	11:48 - 13:41	11:42 - 13:46	11:38 - 13:51	11:33 - 13:55	11:29 - 13:59	11:25 - 14:03	11:21 - 14:06
003	2.30	0:33	12	11:48 - 13:41	11:43 - 13:46	11:38 - 13:50	11:33 - 13:55	11:29 - 13:59	11:25 - 14:02	11:21 - 14:06
004	4.91	1:10	26	11:48 - 13:40	11:43 - 13:45	11:38 - 13:50	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:06
005	0.94	0:13	5	11:48 - 13:40	11:43 - 13:45	11:38 - 13:50	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:06
006	1.79	0:25	9	11:48 - 13:40	11:43 - 13:45	11:38 - 13:50	11:34 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:06
007	4.52	1:04	27	11:49 - 13:39	11:43 - 13:44	11:39 - 13:49	11:34 - 13:53	11:30 - 13:57	11:26 - 14:01	11:22 - 14:05
008	3.46	0:49	17	11:47 - 13:41	11:42 - 13:46	11:37 - 13:51	11:33 - 13:55	11:29 - 13:59	11:25 - 14:03	11:21 - 14:06
009	7.54	1:47	42	11:48 - 13:40	11:43 - 13:45	11:38 - 13:49	11:34 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
010	1.21	0:17	8	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:58	11:25 - 14:01	11:21 - 14:05
011	1.77	0:25	9	11:49 - 13:39	11:43 - 13:44	11:39 - 13:49	11:34 - 13:53	11:30 - 13:57	11:26 - 14:01	11:22 - 14:05
012	8.64	2:03	46	11:48 - 13:40	11:43 - 13:45	11:38 - 13:50	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:06
013	3.53	0:50	18	11:48 - 13:40	11:43 - 13:45	11:38 - 13:49	11:34 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
014	1.22	0:17	8	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:58	11:25 - 14:01	11:21 - 14:05
015	0.96	0:14	5	11:49 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
016	5.20	1:14	26	11:47 - 13:41	11:42 - 13:46	11:37 - 13:51	11:33 - 13:55	11:29 - 13:59	11:24 - 14:03	11:21 - 14:06
017	7.80	1:51	41	11:48 - 13:39	11:43 - 13:45	11:38 - 13:49	11:34 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
018	2.71	0:39	15	11:49 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:30 - 13:57	11:25 - 14:01	11:21 - 14:05
019	3.78	0:54	20	11:47 - 13:41	11:42 - 13:46	11:37 - 13:51	11:33 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:07
020	2.34	0:33	11	11:47 - 13:41	11:42 - 13:46	11:37 - 13:51	11:33 - 13:55	11:28 - 13:59	11:24 - 14:03	11:21 - 14:06
021	1.18	0:17	6	11:47 - 13:41	11:42 - 13:46	11:37 - 13:50	11:33 - 13:55	11:29 - 13:59	11:25 - 14:02	11:21 - 14:06
022	7.33	1:44	36	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
023	2.39	0:34	12	11:49 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:30 - 13:57	11:25 - 14:01	11:21 - 14:05
024	3.49	0:50	16	11:47 - 13:41	11:42 - 13:46	11:37 - 13:51	11:32 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:07
025	3.74	0:53	19	11:47 - 13:41	11:42 - 13:46	11:37 - 13:50	11:33 - 13:55	11:29 - 13:59	11:24 - 14:02	11:21 - 14:06
026	7.41	1:45	36	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
027	1.74	0:25	9	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
028	6.05	1:26	31	11:47 - 13:41	11:42 - 13:46	11:37 - 13:50	11:33 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:06
029	6.59	1:34	30	11:48 - 13:39	11:43 - 13:45	11:38 - 13:49	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
030	2.15	0:31	11	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:34 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
031	6.17	1:28	31	11:47 - 13:41	11:42 - 13:46	11:37 - 13:50	11:33 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:06
032	3.98	0:57	19	11:47 - 13:40	11:42 - 13:45	11:37 - 13:50	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:06
033	1.24	0:18	6	11:48 - 13:40	11:42 - 13:45	11:38 - 13:50	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
034	1.45	0:21	7	11:48 - 13:40	11:43 - 13:45	11:38 - 13:49	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
035	2.11	0:30	10	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:33 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
036	9.15	2:10	46	11:47 - 13:40	11:42 - 13:45	11:37 - 13:50	11:33 - 13:54	11:28 - 13:58	11:24 - 14:02	11:20 - 14:06
037	4.06	0:58	20	11:48 - 13:40	11:42 - 13:45	11:38 - 13:49	11:33 - 13:54	11:29 - 13:58	11:25 - 14:02	11:21 - 14:05
038	9.46	2:15	48	11:47 - 13:40	11:42 - 13:45	11:37 - 13:50	11:33 - 13:54	11:28 - 13:58	11:24 - 14:02	11:20 - 14:06
039	5.78	1:22	29	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:33 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
040	1.60	0:23	8	11:46 - 13:42	11:41 - 13:47	11:36 - 13:52	11:32 - 13:56	11:27 - 14:00	11:23 - 14:04	11:20 - 14:07
041	6.11	1:27	28	11:47 - 13:41	11:41 - 13:46	11:37 - 13:50	11:32 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:06
042	4.96	1:11	24	11:47 - 13:40	11:42 - 13:45	11:37 - 13:50	11:33 - 13:54	11:28 - 13:58	11:24 - 14:02	11:21 - 14:05
043	2.53	0:36	12	11:48 - 13:39	11:42 - 13:44	11:38 - 13:49	11:33 - 13:53	11:29 - 13:58	11:25 - 14:01	11:21 - 14:05
044	1.25	0:18	6	11:48 - 13:39	11:43 - 13:44	11:38 - 13:49	11:33 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
045	13.91	3:18	65	11:47 - 13:40	11:42 - 13:45	11:37 - 13:49	11:33 - 13:54	11:28 - 13:58	11:24 - 14:02	11:20 - 14:06
046	2.43	0:34	11	11:47 - 13:39	11:42 - 13:44	11:37 - 13:49	11:33 - 13:53	11:29 - 13:57	11:25 - 14:01	11:21 - 14:05
047	3.54	0:50	17	11:45 - 13:42	11:40 - 13:47	11:36 - 13:52	11:31 - 13:56	11:27 - 14:00	11:23 - 14:03	11:19 - 14:07
048	13.27	3:09	61	11:47 - 13:39	11:42 - 13:44	11:37 - 13:49	11:33 - 13:53	11:29 - 13:58	11:24 - 14:01	11:21 - 14:05
049	3.17	0:45	16	11:45 - 13:42	11:40 - 13:47	11:36 - 13:52	11:31 - 13:56	11:27 - 14:00	11:23 - 14:04	11:19 - 14:07
050	8.22	1:57	39	11:46 - 13:41	11:41 - 13:46	11:37 - 13:50	11:32 - 13:55	11:28 - 13:59	11:24 - 14:02	11:20 - 14:06
051	6.17	1:28	30	11:47 - 13:39	11:42 - 13:44	11:37 - 13:49	11:33 - 13:53	11:28 - 13:58	11:24 - 14:01	11:20 - 14:05
052	3.14	0:45	16	11:45 - 13:42	11:40 - 13:47	11:36 - 13:52	11:31 - 13:56	11:27 - 14:00	11:23 - 14:04	11:19 - 14:07
053	3.23	0:46	17	11:46 - 13:42	11:41 - 13:47	11:36 - 13:51	11:31 - 13:55	11:27 - 13:59	11:23 - 14:03	11:19 - 14:07
054	3.32	0:47	17	11:46 - 13:41	11:41 - 13:46	11:36 - 13:51	11:32 - 13:55	11:28 - 13:59	11:24 - 14:03	11:20 - 14:06
055	3.09	0:44	16	11:46 - 13:41	11:41 - 13:46	11:37 - 13:50	11:32 - 13:54	11:28 - 13:58	11:24 - 14:02	11:20 - 14:06
056	4.89	1:10	23	11:47 - 13:40	11:42 - 13:45	11:37 - 13:49	11:33 - 13:54	11:28 - 13:58	11:24 - 14:01	11:20 - 14:06

Figure 15: Example Sun Angle Checker Report

Crab

Crab will not exceed 5º between any two consecutive flights or more than 3º on any one flight line. At the earliest opportunity, new imagery will be acquired to replace rejected photographs or flight lines.

5. FLIGHT OPERATIONS QUALITY CONTROL

Quantum Spatial's QA/QC methods for flight operations are founded on strict adherence to our ISO compliant procedures and the strategic design of QC tasks along the workflow path. Any issues that are identified in the field will be re-flown on the next flight date. Relevant QC steps in the digital image acquisition workflow process include:

- Automated flight management systems;
- GPS-supported aircraft navigation interfaced with the camera control software;
- A user-focused interface with touch screen technology to ease configuration and operation and allow in-flight control and review of each image frame;
- Comprehensive mission data recording enabling post-flight analysis of flight results including time, date, altimeter reading, and frame counter without the need to read tapes, drives, or lower speed collection devices;
- The analysis portion of the post-processing allows the technician to view actual acquisition "waypoints," allowing an early decision on re-flight requirements; and
- Flight planning information can automatically populate flight line, photo center, photo names, and camera name data ensuring a smooth post-flight workflow.

6. IMAGE POST PROCESSING

Quantum Spatial's imagery post processing will be based on a centralized post-processing solution at our pixel factory to maximize processing efficiencies, standardization, and quality. Quantum Spatial receives imagery and control data daily from our assigned flight crews. Transmittal data is logged and the storage devices are staged in preparation for downloading.

Figure 16: Quantum Spatial's 1+ petabyte pixel farm

Imagery Download Procedures

Imagery is transferred from the storage drives to our 1+ petabyte pixel farm. Quantum Spatial has developed a proprietary approach that automates this process and includes data integrity validation. Steps include:

Data Checker

Known simply as Data Checker, downloaded data files are compared against the storage drives received from the field deploying an automated methodology. This quality control process confirms that the flight date, UltraCam Eagle sensor-utilized imagery, imagery metadata, and POS data have all been successfully transferred. Upon acceptance of the transfer process, the image-tracking database is automatically updated. Additionally, Data Checker generates both a shapefile and MicroStation (DGN) file depicting the exposures recorded.

Updated Post Processing Backlog

The resulting image acceptance process through Data Checker populates the tracking database and produces backlog-reporting volumes for the post-processing phase. Data Checker reporting includes a complete list of all the flight lines, exposures, and dates, along with a tabular list of the total number of images recorded per flight line. These reports provide hardcopy documentation of the transfer process.

POS Data Processing

The Applanix POSPac software is used to compute an optimal integrated inertial navigation solution. This is accomplished by processing the raw IMU and GPS (collected during the flight) against observables recorded from base station receiver(s). This integrated approach computes a carrier phase GPS solution and then blends it with the inertial data using forward and reverse time processing. This methodology is referred to as a smoothed best estimate of trajectory (SBET) solution. Utilizing the SBET solution of the photo centers, results are converted to the mapping projection, both horizontal and vertical, as well as, the project units.

Imagery Archive and Level 2 Processing

The Image Post Processing starts with the imagery being downloaded from the UltraCam storage unit onto Team networks. Once the imagery is on the network storage location, a check is performed to confirm data consistency before processing to "Level 2". Level 2 is started using custom distributed processing software overtop of the manufacturer's processing software. Meanwhile, overview images are visually checked for misfires, clouds, alignment, etc. This process is done with both the manufacturer's software and in-house developed quality control and management software. During this time, the raw imagery is backed up to tape via the tape library for archiving.

Level 3 Processing and LUT Development

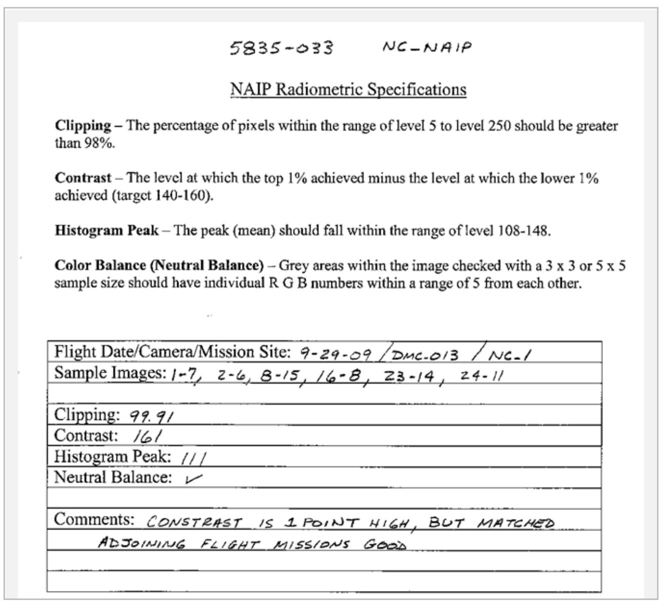
After the imagery is processed to level 2, in-house software is utilized to simultaneously view the PAN, RGB and IR bands to confirm processing and perform another quality control check. The Level 2 imagery will then be processed to Level 3 using Quantum Spatial's distributed system. These delivery product(s) will be based upon our standard specifications which may include an array of products such as 4-band (RGB & NIR) images. All Level 3 imagery will be dodged appropriately to match the image quality and tonal balancing of flight lines acquired on different days.

Quantum Spatial has implemented a "proprietary methodology" for color balancing. This solution achieves the balancing of the individual channels for the PAN, RGB, NIR, and 4-band images. LUTs are utilized to establish a mathematical set of values that transform the input image into a desirable output balance. This process adjusts the gamma, color, contrast, and brightness levels. Emphasis is made during this process to reduce obscurity due to deep shadows to the degree possible while still achieving an overall acceptable image balance with respect to gamma, color, contrast, and brightness levels. "Target" LUTs are developed and then used for the basis of this process and applied to the image database. Quantum Spatial's approach is not strictly a histogram-matching approach. It involves initially obtaining a proper color balance (normally distributed histogram), then balancing the 3-color bands. Visual inspection and review of the radiometric values completes this phase.

Processed Imagery Quality Control/Quality Assurance

Statistical Image Quality Assessment

Statistical image quality assessments are conducted on various flight dates by sensor and mission locations. Assessment includes verification of clipping, contrast, histogram peak, and color balance requirements. Quantum Spatial has found that overall efficiencies are gained by conducting this quality control task in the early stages of the workflow process (as opposed to after orthophoto generation).


5835-033 NC-NAIP

NAIP Radiometric Specifications

Clipping – The percentage of pixels within the range of level 5 to level 250 should be greater than 98%.

Contrast – The level at which the top 1% achieved minus the level at which the lower 1% achieved (target 140-160).

Histogram Peak – The peak (mean) should fall within the range of level 108-148.

Color Balance (Neutral Balance) – Grey areas within the image checked with a 3 x 3 or 5 x 5 sample size should have individual R G B numbers within a range of 5 from each other.

Flight Date/Camera/Mission Site: 9-29-09 / DMC-013 / NC-1
Sample Images: 1-7, 2-6, 8-15, 16-8, 23-14, 24-11
Clipping: 99.91
Contrast: 161
Histogram Peak: 111
Neutral Balance: ✓
Comments: CONSTRAST IS 1 POINT HIGH, BUT MATCHED
ADJOINING FLIGHT MISSIONS GOOD

Figure 17: Example Assessment Report

Assessment Reporting

As depicted in Figure 17, assessment reports manually document the results from the image quality assessment samples.

Image Checker

Image Checker is another Quantum Spatial custom application that supports visual quality inspection. Thumbnails are generated for each frame. Visual inspection checks for potential image anomalies, clouds, smoke, haze, and frame overlap adherence.

The operator initially inspects an entire mission area from the georeferenced images for the purpose of validating overall completeness and tonal quality. Additionally, adjoining mission-to-mission comparisons are performed. Finally, an inspection is conducted on each frame along the flight line. As depicted in Figure 18, the user can also click on one of four pixel images at the bottom of the display screen. These are the four corners of the TIFFs at 1:1 pixel resolution to check for registration. If the user clicks on one of these images, a larger section of that image is displayed on the main view for more detailed inspection. As the final phase of image quality acceptance prior to orthophoto generation, the image can be accepted, rejected, or flagged as questionable (requiring second opinion inspection). Comments can also be tagged to the exposure.

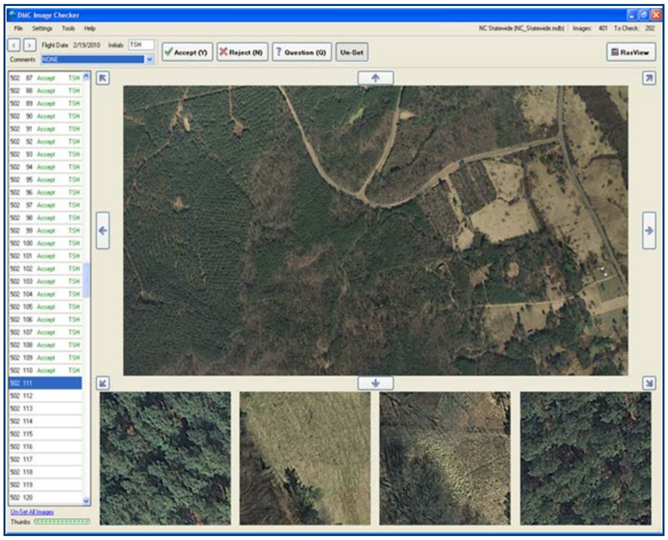


Figure 18: Image Checker

As an integrated component of Quantum Spatial's image-tracking management tool, exposure acceptance at this phase also triggers status updates to the projects master database. This provides real-time status reporting on exposures that have passed three phases of quality acceptance and are available for orthophoto production. A QA/QC report verifying Quantum Spatial's QC process for the imagery will be provided with each processed image delivery.

Quantum Spatial will provide processed imagery samples to Commission for review prior to processing each production block. Commission will review the samples and make recommendations on any changes, if necessary. Once the changes have been made, Quantum Spatial will resubmit them for final approval. The approved samples shall provide a baseline for post-processing the remaining imagery.

Quantum Spatial understands that it will not be authorized to begin digital orthophoto production until the post-processed images for each production block have been thoroughly catalogued, reviewed, and approved by Commission.

7. DISPOSITION OF AERIAL IMAGERY

All imagery obtained by Quantum Spatial will be the property of Commission. Quantum Spatial will store the processed digital camera files from the aerial mission at no cost to the Commission indefinitely. Additionally, flight logs maintained by pilots and cameramen will be maintained and delivered to Commission at the completion of the aerial mission phase of the project if requested.

Aerial Photography Deliverables

Quantum Spatial will deliver the following items from the aerial photographic mission:

1. Planned photo centers in shapefile format with attributes including corresponding line and frame number;
2. As flown, photo centers in shapefile format with attributes including corresponding line and frame number that correlates to the final post-processed TIFF images. Attributes will include the date of photography and a time stamp for acquisition to be used to verify the correct sun angle;
3. Aerial photography mission logs;
4. Process imagery samples;

5. Any and all aerial imagery has always been construed legally as instruments of Professional Services., and retained by a Geospatial Professional firm whom was responsible for their acquisition. The proper care and maintenance of the data is best managed by the Professional, thus the offer to retain the data at no cost. In the event the Commission elects to take possession of the imagery this could be facilitated once all legal waivers of liability have been completed between our firm and the Commission.

8. LIDAR

Quantum Spatial possesses all the organic resources required for the collection and post-processing of airborne LiDAR datasets. These resources include aircraft with inertial navigation systems; multi-pulse sensors; GPS equipment; post-processing computer infrastructure; and a professional staff with more than a decade of LiDAR processing expertise. Quantum Spatial owns and operates fourteen LiDAR units consisting of four Leica ALS70s, three Optech Gemini, four Leica ALS50 II, two Orion H, and One Reigl 480I sensors. Quantum Spatial's Leica ALS70 LiDAR sensors are capable of 500 kHz pulse rate critical to supporting the higher density return requirements associated with Quality Level 1 and 2 density requirements, 8ppsm and 2ppsm respective. The Quantum Spatial Team's combined collection assets include a total of 24 aircraft configured with airborne GPS (ABGPS), dual frequency GNSS antennas, and inertial measurement unit (IMU) configurations.

Figure 19: LiDAR Data Acquisition & Processing
Quantum Spatial operate a nation-leading compliment of 14 LiDAR sensors as listed.
Quantum Spatial's combined collection assets include a total of 24 aircraft configured with airborne GPS, dual frequency GNSS antennas, and inertial measurement unit configurations.
Quantum Spatial staff maintains proficiency in the delivery of LiDAR datasets to various specifications including adherence to USGS v1 standards and FEMA Specifications for Flood Hazard Mapping.
Quantum Spatial performs two levels of LiDAR boresighting and system testing to validate the calibration of equipment prior to data acquisition.
Quantum Spatial's LiDAR distributed post-processing environment utilizes GeoCue LiDAR integration tools for workflow management tasks.
Quantum Spatial's survey crew will establish GPS QA checkpoint locations to test and validate the FVA, CVA and SVA of LiDAR bare earth datasets.

The Team's flight operations expertise spans 50 years of operations and includes crews that have logged tens of thousands of flight hours. Our entire fleet of single and twin engine aircraft can be configured to support LiDAR data collection; however, Quantum Spatial routinely deploys single-engine, high-performance aircraft for this purpose (see Figure 20).

Figure 20: One of Quantum Spatial's single-engine aircraft used for LiDAR acquisition

LiDAR Scoping & Specifications Adherence

All new LiDAR acquired and processed by Quantum Spatial would be completed in full compliance with US Geological Survey National Geospatial Program Base LiDAR Specification, Version 1 (TM11-B4) and could involve a minimal collection area of an entire County at one time. As a USGS GPSC contractor, Quantum Spatial fully understands and routinely delivers LiDAR datasets to USGS compliant with these specifications. Current USGS tasking includes 5,600 square miles of QL2 (2ppsm and 4ppsm), 0.7m NPS, 9.25cm RMSEz and QL3 (1ppsm), 1m NPS, 18.5cm RMSEz hydro flattened terrain data in support of the 2013 South Platte River Watershed Flooding Disaster in Colorado. Other current USGS task orders include 1,600 square miles near Rutland, VT at QL2 (2ppsm & 4ppsm), 0.7m NPS, 9.25cm RMSEz and 1,800 square miles in the Shenandoah Valley of Virginia also at the same specifications as Rutland. Currently we are involved with the collection and processing of 1600 square miles of QL2 (2ppsm and 4ppsm), 0.7m NPS, 9.25cm RMSEz and 2400 square miles of QL3 (1ppsm), 1m NPS, 18.5cm RMSEz hydro flattened terrain data in the State of Illinois.

Collection and Processing Workflow

As depicted in Figure 21, Quantum Spatial has developed a detailed LiDAR workflow methodology that is founded on professional expertise, understanding of the technology, and well-documented record-of-performance. Their processing procedures are generally divided into three phases of operation that include flight acquisition, field survey, and dataset post-processing. Designed into this methodology are six primary milestone quality control tasks (noted numerically on the workflow diagram) coupled with numerous sub-task validation steps.

Quantum Spatial will deliver a project work plan containing the required elements outlined in the RFP to Commission for its review and approval prior to any collection activities. The plan will be customized to reflect the final contracted areas (regional or county based) and technical specifications.

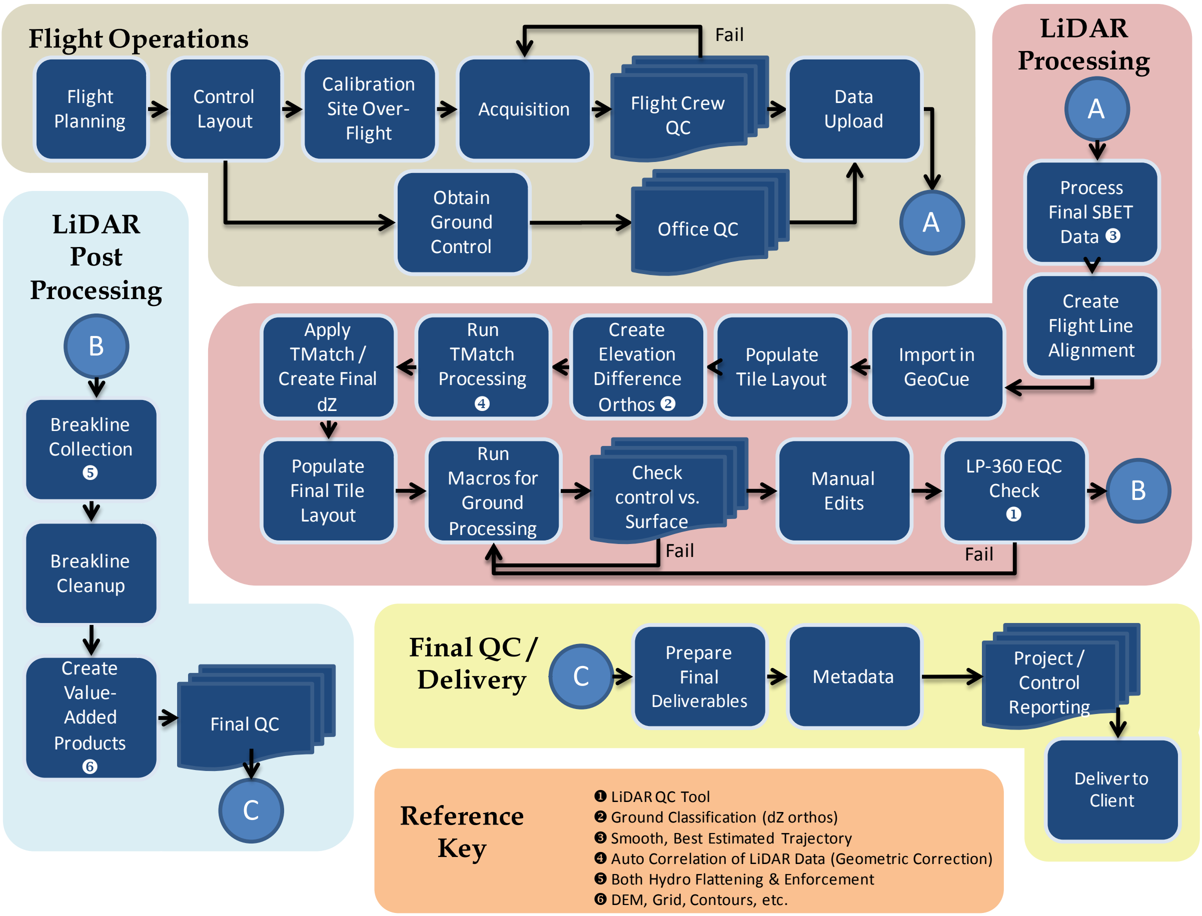


Figure 21: Quantum Spatial's LiDAR Workflow Methodology

Flight Operations

The initial phase of LiDAR flight operations commences with project planning. Quantum Spatial utilizes a combination of sensor manufactures flight planning utility tools in combination with programs such as XMAP designed for layout design. Two stages of acquisition planning are conducted for each project (preliminary and operational). Preliminary planning facilitates an understanding of the level of effort required to undertake each project. Local airport staging locations are identified, along with potential ground control positioning (base stationing, production control, blind point control). Continually operating reference stations (CORS) are researched for utilization in the control phase.

Collection Parameters

A LiDAR data could be collected at minimum, a nominal post spacing of 1m (QL3) using an approved fully calibrated system capable of collecting multiple echoes per pulse with a minimum of a first, last, and one intermediate return as well as intensity (LiDAR pulse signal strength) for each return signal. Other options are available.

Sensor Calibration

The success of any LiDAR mission is directly contingent on the accurate determination of all the positional and alignment parameters of the sensor in the aircraft. Quantum Spatial performs two levels of LiDAR boresighting and system testing to validate the calibration of our equipment prior to data acquisition. Periodic calibrations are conducted at its permanent calibration facility located in Sheboygan, WI and Frankfort, KY. Additionally, project-specific boresight calibration is locally conducted on each sensor at commencement and completion.

LiDAR Collection

Flight acquisition of LiDAR data covering the contracted area(s) would be conducted by Quantum Spatial during the Spring 2015. Commission consent will be sought by Quantum Spatial before the initial project data collection commences. Quantum Spatial will operate our LiDAR Sensors during optimal PDOP conditions (maximum of three) during daylight or evening hours. The atmosphere will be cloud and fog-free between the aircraft and the ground. The ground will be snow-free; however, very light undrafted snow may be deemed acceptable, given prior approval. No collection will occur during unusual flooding or inundation conditions.

Flight crews will set up multiple GPS base stations prior to each day’s flights. They will also remove the GPS base stations and download the raw GPS observation data at the end of each day. Observation data is typically submitted on a daily basis to the NGS Online Positioning User Service (OPUS), and the resulting position and quality factors from the OPUS solution is carefully evaluated. These are compared to the published NGS position of the monument that was occupied. Any issues are addressed immediately to ensure that all acquired data is appropriate for final post-processing and to further ensure that flying days are not lost.

Acquisition Quality Control

Quantum Spatial flight crews maintain detailed flight reporting that covering each LiDAR lift and all lines collected. Specifics regarding the aircraft and sensor utilized, atmospheric/ground conditions, and sensor parameters are recorded. Additionally, crews undertake a quality control review of the collected data prior to leaving the field. This includes insuring that project area is fully and sufficiently covered with no data voids due to data holidays (i.e. gaps between flight lines) and/or from system malfunctions.

LiDAR Control Surveys/Ground Control & Check Point Surveys

Quantum Spatial survey could establish the required LiDAR ground control to support bias (z-shift) control establishment. Z-shift process is a means of conducting a control bias analysis and applying final adjustment to LiDAR surface. Survey Teams could also collect QA checkpoints to validate the FVA, SVA and CVA accuracies of the final bare earth LiDAR surfaces (see Figure 22). The exact quantity and location of required ground control and checkpoint control locations will be determined and provided to Commission once the final project limits and accuracies are defined but will follow the general guidelines required in USGS V1 specification.

The Commission is intensely aware of the extensive 3D geodetic control they have designed and maintain throughout the Region. Much of this control survey network was field surveyed by Quantum Spatial. Based upon the known control density, we anticipate most of the required control to facilitate imagery or LiDAR projects may be extracted from the existing control records. This survey data may be incorporated into the fabric of the imagery or

LiDAR processing campaigns via aerial targeting or limited field measurements to elevate the existing control to pavement elevations to support LiDAR indexing. Once the final version of the 2015 program has been determined (imagery and LiDAR), we would meet with the Commission to recommend the most appropriate use of the existing data to facilitate each program requirement.

Airborne Data Processing

Data returning from the field includes the LiDAR, ABGPS, and inertial data (critical to the positioning of the sensor during flight). Processing technicians and surveyors will initially post-process the dataset using sensor manufactures software platforms (contingent on sensor source). A smoothed best estimate of trajectory (SBET) is established, blends the post-processed aircraft position with attitude data. The SBET position is then associated with each laser point in development of the point cloud, which is the mathematical 3-D collection of all returns from every laser pulse. Data is generated as flight lines strips in LAS format (ASPRS standard), in preparation for analysis, filtering, and classification. The LAS data is established in final projection based on specified datum. Data will also be reviewed by processing technicians prior to classification to validate conformance to USGS V1 specifications to confirm compliance to FVA, NPS, Spatial Distribution and Data Voids specifications. Any mission data found to be non-compliant will be re-flown at no charge.

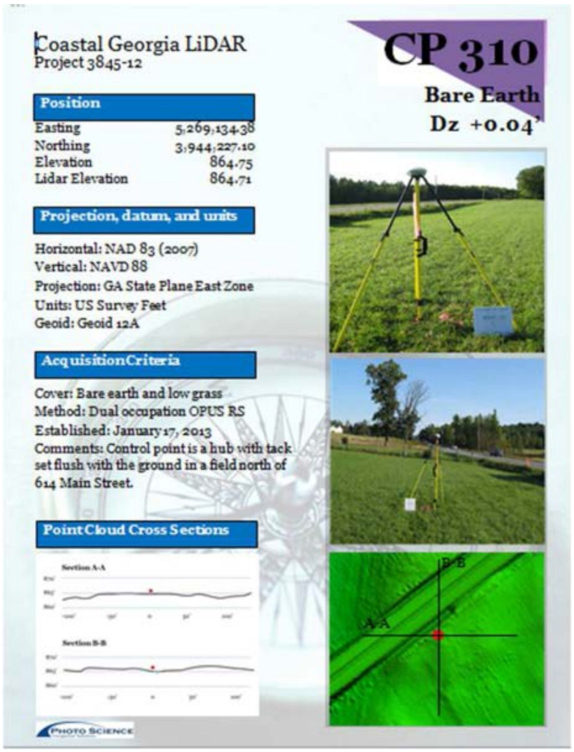


Figure 22: Sample Bare Earth Checkpoints

LiDAR Data Post-Processing

The Quantum Spatial Team utilizes GeoCue LiDAR integration tools for the remaining workflow management tasks. The SBET-generated LiDAR flight lines, project boundary, and tile schema are ingested for processing. Flight trajectories are created to establish the swath nadir of each flight line. Additionally, the project tile schema established in collaboration with the Commission would be populated from the flight strip, establishing a more efficient file size management solution.

Flight Line Analysis & Calibration

Quantum Spatial performs a line-to-line analysis and relative adjustment on the dataset to compensate for potential systematic error that may have been introduced into the process. This is accomplished through the generation of LiDAR intensity images, referred to as dZ orthos. This process serves as a visual quality control process to isolate and adjust vertical differences on discrete points between lines. Utilizing customized routines and GeoCue software, the vertical overlap is analyzed and color coded to flag differences between each strip. Once the calibration points between strips are identified, TerraMatch (MDL residing on MicroStation) performs the flight line calibration adjustment. dZ orthos are again created as a quality control assessment. Upon acceptance, the computed TMatch adjustments are applied and the final LiDAR tiles are populated in GeoCue.

Point Cloud Processing

The Quantum Spatial Team utilizes GeoCue's TerraScan and TerraModeler applications to automate data classification, bare-earth generation, and the stream lining of manual cleanup operations. As depicted in Figure 23, project-specific parameters are entered for bare-earth processing and flight overlap classification and removal, as examples. Key project-specific variables such as point characteristics and classification maximums (terrain and iteration angles) are established in this phase. Quantum Spatial has developed specification standards for this processing phase through development of customized variable macros. These proprietary macros are the result of several hundred man-hours of standards development, forming a means of project-to-project results consistency and quality assurance sustainment.

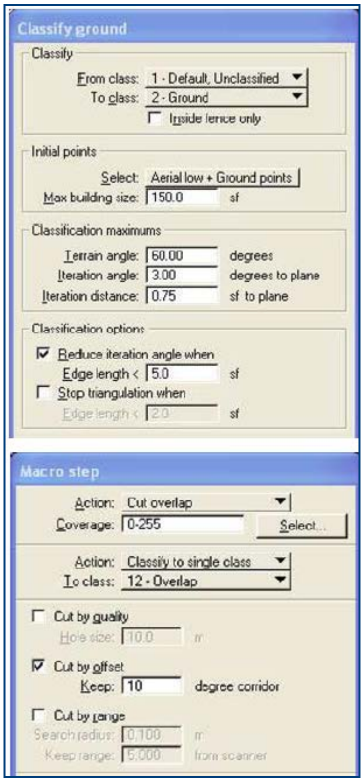


Figure 23: Point Cloud Processing

Classified LiDAR point data will be delivered in LAS files utilizing the latest LAS specification (currently LAS 1.2 or 1.3) containing all LAS items of Point Data Record Format 1. The header file will contain all system generated LAS items as defined in the Public Header Block and as a minimum will contain the "File Creation Year Day" and "File Creation Year," which represents the final deliverable generated LAS date. The projection information for the point data will be specified in the Variable Length Record using the appropriate GeoTIFF tags. No points will be deleted from the LAS file.

The classification codes would follow the ASPRS Standard LiDAR Point Classes and USGS V1 specification utilizing the following:

- Code 1 – Processed, but unclassified
- Code 2 – Bare-earth ground
- Code 7 – Noise (low or high, manually identified, if needed
- Code 9 – Water
- Code 10 – Ignored Ground (Breakline Proximity)
- Code 17 – Overlap Default
- Code 18 – Overlap Ground
- Code 25 – Overlap Water

Manual Clean-up & Quality Control

All data is manually reviewed by LiDAR processing technicians for the purpose of artifact removal and verification of class assignments, using the functionality provided by TerraScan and TerraModeler applications. QT Modeler is used as a final check of the bare earth dataset. The automated generation of a ground classification is not solely relied upon to create a final surface. As presented in Figure 24 below for example (left-to-right), the automated routine failed to classify and remove points likely associated with building and/or vegetation. In the second example, over-filtering has yielded "long triangles" along the shoreline which is a strong indicator of over-filtering. The third example properly depicts the surface resulting from the proper deployment of a combined automated/manual clean up methodology.

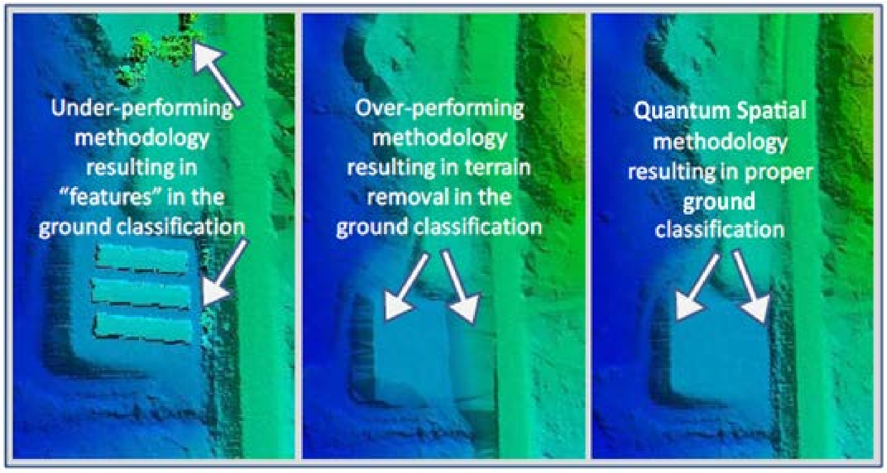


Figure 24: Manual Clean-up & Quality Control

The Team's automated and manual filtering for LiDAR products will use the following minimum performance for artifact/feature removal from the bare earth surface model:

- 90% of artifacts classified
- 95% of outliers classified
- 95% of vegetation classified
- 98% of buildings classified

Special care will be taken by processing technicians during the classification process due to the geographic nature of the selective areas (i.e. coastal regions) within the overall project area which consists of extremely flat terrain mixed with important hydrographic characteristics. To the degree possible and practical without the use of hydrographic break lines, channel geometry of streams and drainage features will be maintained as well as the ability to identify sand bar features and swamp areas. Dense vegetation data voids will also be minimized by the automatic removal process and "over smoothing" due to aggressive classification will be avoided.

Multi-tile QC Assessment

Team members use GeoCue's LP360EQC application as a final means of quality verification prior to accuracy reporting. The LP360 product line is comprehensive extension for the Esri ArcGIS desktop environment that supports redlining and LiDAR data evaluation. This extension uses a specially designed ArcMap data layer to access points directly from industry standard LAS files. Up this phase of production, processing, edit, and quality control assessment are conducted on an individual tile basis (micro level). LP360 supports the viewing and edit of the dataset across multiple tiles simultaneously (macro level). This capability provides a quality data continuity assessment across tile boundaries.

LiDAR QA

The QA Team will utilize Quantum Spatial's FOCUS (Final Observed Calculations and Users Statistics) QA toolset to test, validate and certify that the LiDAR deliverables meet the USGS LiDAR Base Specifications v1.0.

Standard USGS V1 LiDAR Deliverables

- Unclassified .LAS, v1.2 or 1.3 Point Cloud in swath format
- Classified .LAS files, 1.2 or 1.3 in tiles format

- Hydro Flattened DEM in .IMG or equivalent in tile format
- LiDAR Intensity Imagery, GeoTIFF format in tile format
- One Esri file geodatabase containing the requisite hydro break lines
- As-flown flight line swaths in shapefile format with attributes including corresponding line number. This will also include an attribute for the data of acquisition for each line;
- One FGDC-compliant metadata at Project and each LiDAR product type produced
- Control Survey Report
- QA Report
- Project Report

9. OBLIQUE IMAGERY

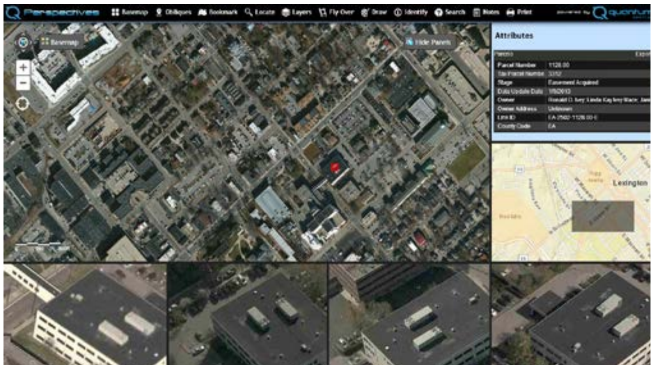
Figure 25: Advantages of Quantum Spatial's Oblique Solution
Simultaneous capture of nadir, and multi-directional photography
High overlap in the obliques provide multiple views of structures
45^{o} look angle maximizes the usefulness of the obliques
High accuracy provides significant value of the imagery for multiple applications

Oblique imagery is an incredibly valuable resource to cities, counties, and regional governments. Imagery captured by oblique systems provides a view of the landscape that is very similar to what we see in our everyday life and may provide greater additional information than is discernible from only vertical aerial imagery. Oblique images are particularly useful for analyzing development, accurately planning for emergency response, gaining multiple look angles to better identify structures located below dense overhanging vegetation, identifying potential encroachments of utility and transportation rights-of-way, and better assessing the overall land use and characterization of wide areas.

Quantum Spatial Perspectives is a comprehensive oblique viewer software application. Perspectives not only provides the user with a visual viewpoint of oblique and vertical imagery, but it is also a fully integrated GIS with numerous enhanced capabilities including navigation, multiple basemap display, identify, search, flyover creation, measurements, import/export functionality, and much more. The Perspectives application can be used across all markets including Energy, Environmental, Transportation, and Government. Perspectives can also be provided on different software platforms including web-based, desktop ESRI extension, or as a stand-alone application. Whether the user is performing large corridor/route studies or small block area analysis, Perspectives is the application tool that can be utilized for the many oblique viewer needs currently being sought in today's marketplace.

APPLICATIONS OF *PERSPECTIVES*

- Energy/Utilities
  - Natural Gas Pipeline
  - Electric Transmission Line
- Transportation
  - Road/Railroad Corridor
  - Airports
- Environmental
  - Hydrology
  - Vegetation
- Government
  - Land Use and Permitting



- Urban Planning
- Public Safety
- Disaster Response

FUNCTIONALITY & FEATURES OF *PERSPECTIVES*

- Full Navigation Toolbar
- Locate Tool
  - By address or coordinates
- Layer Display
  - Customized by zoom level
- Multiple Basemap Display
- Identify Tool
- Search Tool
  - By location or geodatabase
- Add Bookmarks
- Draw Points & Polygons
  - Includes save and open function
- Create & Edit Notes
  - Export notes and location to a geodatabase or shapefile and XL
- Create Image to Image Flyover
  - Multiple start/stop options with pause/resume
- Measure in basemap/vertical imagery
- Connect to SDE geodatabase
- Multiple perspective windows
  - Vertical
  - Forward oblique
  - Backward oblique
- Save & Print
  - Save/Print screenshots of entire view or individual oblique views
  - Save original oblique images

BENEFITS OF *PERSPECTIVES*

- Much more than a simple oblique viewer
- Fully integrated GIS
- User friendly
- Multiple software platforms
- Enhanced capabilities and features
- No Licensing restrictions

Our oblique system is installed in a custom modified single engine Cessna 206 aircraft that provides a near perfect combination of flying height, stability, speed, and fuel capacity to be a very productive aerial platform. To date we have employed this solution in urban environments, pipelines, electric transmission, roadways, and railways with ground resolutions ranging from 2 to 12-inches.

Sensor Design

Our professionals worked with Leica Geosystems (Heerbrugg, Switzerland) for more than a year on the design of our oblique camera system. We made modification to their original design to alter the lens configuration so that an equivalent ground resolution is captured in both obliques and the nadir imagery; to employ a more accurate control system onboard that has resulted in superior accuracy; and to alter the look angle from 40-45º, which we believe provides considerably better information in the imagery. Our modifications are now standard on the design of Leica's oblique sensor.

Our Leica RCD 30 system has performed flawlessly on numerous projects and applications since its installation two years ago. This system includes:

- 4–60 Mega Pixel RGB (true color) cameras for the multi-directional obliques oriented at 45º look angles
- 1–60 Megapixel nadir (down) camera capturing RGB and Near Infrared (NIR) imagery
- Precise Inertial Navigation System (INS) that provides very accurate positioning and measurement within all images
- Storage for multiple days airborne missions

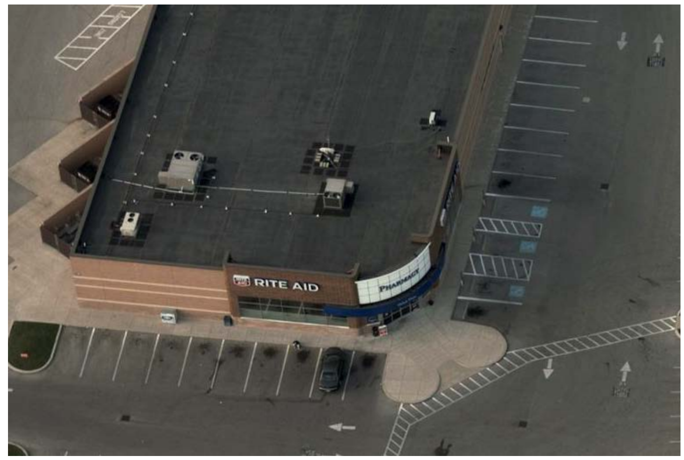


Figure 26 – Oblique imagery provides an ideal option of viewing the developed environment.

The 60 Mega Pixel cameras provide very large format images as compared to similar systems in use today. The larger footprint maximizes the value of our oblique solution and allows for significant overlap in the captured images. Four way obliques in each of the cardinal directions are captured with flight lines oriented in either north/south or east/west directions. This allows us precise capture of all images at pre-planned exposure stations.

Image Viewing

For oblique imagery to realize its full potential in the utility sector, it is very important to use this imagery with an intelligent viewer that allows you to drive to any location and retrieve all the imagery (nadir and obliques) that cover your area of interest. Our viewer is provided with all our oblique deliverables and can run either in either a standalone windows-based environment, or work in conjunction with Esri GIS environment.

Our viewer has the ability to render GIS information over both nadir and oblique images. This might include the parcel information, rights of way, utilities, and other valuable information. We will work with you to custom configure the viewing system to maximize the value of this new information across your enterprise.

Figure 27 – Quantum Spatial's oblique sensor simultaneously captures nadir, forward, and aft oblique photography

Figure 28: Quantum Spatial's Oblique Acquisition Strategy

Flying Height	4,500-ft above ground
Nominal Pixel Resolution	6-inch
Nominal Swath Width	4,562-ft wide
Planned Exposure Distance	1,200-ft
Oblique Format	RGB (true color)
Nadir (vertical) Imagery	RGB + NIR (infrared)

Acquisition Strategy

If selected for this project, we will mobilize our oblique sensor to the appropriate areas of southern Wisconsin during the period agreed upon (leaf-on or leaf-off) during 2015. Our strategy will be to move generally from south to north within the selected areas. It has always been important to our clientele to capture both the oblique and vertical images with higher sun angles to minimize the effects of shadows. Figure 28 provides a detailed example of information related to an oblique acquisition mission to achieve a specified pixel resolution. The parameters are appropriately altered based upon the final pixel resolution agreed upon.

Base Station Strategy

We recognize that attaining a very high accuracy within the oblique imagery is important to the overall success of this project. We use a highly accurate Inertial Navigation System (INS) integrated with the oblique sensor that provides the accurate position and orientation of every imagery frame captured during the project. The INS uses GPS technology to provide the 3D position (XYZ) and accelerometers and gyroscopes to provide the 3D angular orientation (Omega, Phi, and Kappa).

This means that features identified and positioned on the ground using the oblique imagery will provide accurate, reliable information. It also means that this oblique imagery can be accurately integrated with the centerline of our flight lines, and further that the oblique imagery will fit accurately with the vertical aerial imagery and the elevation models derived from LiDAR acquisition.

To achieve the highest accuracy from this system, we will post process the raw data captured in the aircraft against known points on the ground where GPS observation data is captured simultaneously during the acquisition. We use both observation data captured by base stations that we set up and observe during acquisition, and the Continuously Operating Reference System (CORS) network that is maintained and managed by the US government's National Geodetic Survey (NGS). Additional information is available at www.ngs.noaa.gov/cors/.

The accuracy of the data gained from this post processing is dependent on a number of factors, but the two most important are the strength of the GPS satellite configuration during the times of flight (and this changes throughout the day) and the distance of the aircraft as measured from the base station location used in the post processing. We carefully plan for acquisition during times of the day when the GPS constellation is quite strong (that can be pre-planned each day from government supplied predictive information), and intentionally limit the distance that we fly in comparison to the base stations used in the post processing. This provides the utmost in accuracy for the Commission from the acquired data.

10. GROUND CONTROL SURVEYS

Quantum Spatial's in-house Geomatics department would complete the ground control survey phase to support project requirements. Quantum Spatial will coordinate with the Commission to determine if existing points can be used (retargeted or photo ID) as part of the overall photo control solution to meet specified horizontal accuracies as previously stated. Additionally, Quantum Spatial's standard QA procedure will be to either establish or utilize existing QA blind points throughout the mapping areas (these points will be used to verify preliminary aerotriangulation solution, LiDAR indexing and orthophoto accuracy). Quantum Spatial's photo and quality control plan is designed to maximize the use of existing control points previously established and/or recovered.

11. AEROTRIANGULATION

As highlighted in Figure 29, the Quantum Spatial Team will utilize Intergraph's ISAT systems for softcopy aerotriangulation and pass-point selection techniques. The Team's experience in analytical triangulation includes large-block solutions based on ABGPS and inertial methods. As an integrated component of the Team's fully digital workflow environment, our methodology reduces the overall time and expense associated with analytical triangulation, while ensuring a maximum level of accuracy is attained.

The Quantum Spatial production team members will select three points down the center of each frame. This will result in a minimum of six points per stereo neat model. These points will be used to tie individual models together along a flight strip. Flight tie points will be established every model to tie adjacent flight lines together. An automatic image correlation technique will be utilized to perform final point sub-pixel measurement. Each point receives a unique point number, "keying" each point to an individual digital frame and frame location. Additionally, each block will be successively coupled together with the selection of tie pass points along their respective borders with adjoining blocks. The block tie points will also be included in the bundle adjustment.

Figure 29: Aerial Aerotriangulation
Quantum Spatial will utilize Intergraph's ISAT softcopy aerotriangulation software as part of our fully digital workflow environment.
Automatic image correlation technique enable production cost efficiencies.
Unique point number "keying" strategy is utilized aerotriangulation QC.
Point "targeting" will enable aerotriangulation and digital orthophoto coordinate comparisons by both Quantum Spatial and Commission QA assessment.
Quantum Spatial uses the most rigorous algorithm - least squares block bundle adjustment for achieving a best-fit solution of measured points.

The Team's point numbering sequence is a QC process, designed to prevent incorrect control point duplication within the blocks. The output ISAT production system generates point coordinates in both the refined coordinate system and raster system (rows and columns). The first is used in performing the aerotriangulation reductions while the second may be used to "post PUG" the measured points for later use in QC procedures.

12. DIGITAL ELEVATION MODEL (DEM) PROCESSING

After the aerial data collection by Quantum Spatial flight crews, our production personnel inspect, and document existing bare earth LiDAR DEM sources in order to validate data format, geographic coverage, and data fidelity with respect to the orthophoto production process. Once the LiDAR DEM sources for a production block have passed this initial review, Quantum Spatial Team members will ingest all of the DEM point data sources for a block into the GeoCue software environment. The tools provided in GeoCue will allow for the data to be populated into a common tile layout.

Then using tools within TerraScan and TerraModeler, the data will be reviewed to determine how well the DEM datasets vertically match. The process involves defining acceptable vertical offsets based on experience and overall accuracy requirements. Areas of significant vertical differences are identified for possible adjustment using different methodologies based on the magnitude of vertical offset. During this review process, the quality of the horizontal match between existing data sets is also manually reviewed to look for any unacceptable horizontal shift between data sets. Horizontal adjustments can also be accomplished, if necessary. Once the DEM passes this review, the combined point data from all sources within a block are intelligently filtered to create a model key (subset) point file of a sufficient point density to support orthorectification that will meet the required horizontal accuracies. These point files then proceed forward into orthophoto production. Quantum Spatial will use the DEM point source used to perform the orthorectification segmented by County in geodatabase point format. This DEM would incorporate any required changes made to the original DEM source files, and be returned to the Commission per previous and established contractual procedures.

13. DIGITAL ORTHOPHOTOGRAPHY

Quantum Spatial has been generating digital orthophotography since 1992 and maintain extensive production capabilities (see Figure 30). The Quantum Spatial maintains complete "in-house" hardware and software capabilities for a fully digital workflow process necessary to develop 1"=100', 4-band (RGB & NIR), 8-bit-per-band digital orthophotos with 0.25-ft, 0.5-ft and/or 1-ft ground pixel resolutions. All digital orthophotography produced by the Quantum Spatial Team will be in accordance with the quantitative and qualitative accuracy requirements outlined in the RFP.

All primary orthophoto deliverables will be in GeoTIFF format to allow for easy re-projection in ArcGIS. The .tfw files will also be delivered with each GeoTIFF file to facilitate viewing in a variety of software environments.

Figure 30: Digital Orthophotos
Quantum Spatial's imagery sensors maximize the Commission's imagery application capabilities with a single-pass, offering multiple options for orthophoto deliverable formats.
Quantum Spatial rectification methodology is designed for efficiency, while maintaining accurate orthophotos to the highest of visual qualities.
Quantum Spatial's 1+ petabytes of online storage sustains 24-hour-per-day orthorectification, dodging, tonal balance, and batch metadata routines.
Only cubic convolution resampling is utilized, as it is considered a superior methodology over nearest neighbor or bilinear approaches.
Two-tone matching processes are performed to maximize image quality, mitigate "hotspots," and ensure an even overall pixel histogram.
Manual and automated seam line production approach optimizes final image quality.

Processing Environment

Quantum Spatial operates one of the largest pixel-processing farms in the country, as depicted in Figure 31. With over 1 petabytes of online storage, Quantum Spatial now maintains the infrastructure to sustain 24-hour-per-day orthorectification, dodging, tonal balance, and batch metadata routines.

Orthophoto Tile Coverage

As earlier referenced this Technical Approach, Quantum Spatial understands that the existing tile layout previously employed by our firm will be used to develop and deliver the potential various pixel resolution, GeoTIFF orthophoto datasets.

Production & Delivery Formats

Each primary set of RGB GSD digital orthophoto tiles will be produced and delivered in GeoTIFF format along with accompanying .tfw files in US Survey Feet. This dataset will be organized and delivered in countywide format.

Figure 31: Quantum Spatial's 1+ petabyte pixel farm

Orthorectification

Quantum Spatial's digital orthorectification process relies on four primary production data sources including digital aerial imagery, camera calibration data, ground and airborne control/aerotriangulation data, and the DEM sources. Quantum Spatial's methodology will fully comply with RFP requirements.

Quantum Spatial's orthorectification process begins upon acceptance of imagery through Data Checker and the creation of the exterior orientation data. Utilizing Intergraph's Image Station Photogrammetric Manager (ISPM) application, project parameters are assembled. OrthoPro is then utilized to spatially overlay information extracted from ISPM with corresponding surface data. OrthoPro then creates the rectified images, generates seam lines, and mosaics the rectified images into larger blocks. Working in larger seam-matched blocks has been proven to yield greater efficiency in the post-ortho quality review process. Key steps in the orthophoto generation process include:

- Defining project parameters (coordinate system, units and file format)
- Ingest of production block project wide surfaces (elevation data)
- Utilization of exterior orientation (EO) files
- Rectification
- Automated/manual seam line placement, mosaicking, and final color balancing
- Horizontal accuracy acceptance

The Quantum Spatial Team production approach ortho rectifies every image frame acquired during the photo missions but typically utilizes approximately 80–90% of the rectified image frames in the mosaicking process. This methodology maximizes production cost efficiency, while maintaining accurate orthophotos to the highest of visual quality standards. Quantum Spatial's QC process validates the fit of the orthophotos during this production phase. Exception areas to this workflow process are commonly found in urbanized areas with very tall structures. Quantum Spatial will rectify and use every frame obtained in these areas, specifically using only the center portion of every frame. When supplemental imagery acquired to prepare "near true ortho" in urban areas to further reduce structure lean, it will also be rectified and used in the post-mosaicking finishing process whenever building lean cannot be sufficiently reduced using the primary imagery. These processes combined greatly reduce the effects of radial displacement on tall features. We have completed these same processing procedures in communication with all previous projects for the Commission.

The rectification process employs a cubic convolution resampling method, which sharpens the edges of linear features by sampling 16 of the closest pixels and performs a weighted adjustment; whereas alternatively, nearest neighbor resampling tends to result in jagged linear features, while bilinear resampling creates "fuzzy" linear features.

Mosaicking & Balancing

Mosaicking is accomplished using OrthoPro software. Image blocks are processed using two distinct tonal matching functions. Each image is processed to remove any hotspots in the middle of the frame. During the collection of aerial imagery, more light enters the lens from directly below the camera than does from the corners of the frame. Even though filters are designed to minimize this effect, some hotspots still can occur. Additionally, all of the frames undergo a histogram comparison process and then are matched to provide a seamless tone image.

For optimal production performance in rural areas only, Quantum Spatial initiates an automatic seam line creation strategy for image mosaicking. Auto-generated seam lines are reviewed and manually adjusted to avoid buildings and other features depicting discontinuity. The mosaic is then reprocessed using manual seam lines to maximize image quality. Quantum Spatial typically performs manual seam line placement in suburban/urban areas in order to provide the highest quality results.

During the mosaicking process, seam lines are feathered to provide a smooth transition from one image to another in order to develop a seamless orthophoto data set across the project area that can then be tiled to meet project tiling schema. As depicted in Figure 32, an "automated-only" approach to seam line generation can deliver poor quality seam line results. Production Team members utilize a combined automated/manual methodology for maximum cost efficiency and image quality. Tonal matching is accomplished by comparing pixel values in the overlap area of all images. The software modifies the histograms of the individual images to achieve an overall mosaic, which will have a uniform tone throughout the images.

Figure 32: Quantum Spatial OrthoPro Software

Tiling

Once the mosaicking process is complete, Quantum Spatial will utilize the existing tiling schemas to "cut" the final orthophoto tiles from the mosaics. This will result in the development of a seamless, edge-matched data set adhering to a uniform tiling schema.

Production Quality Assurance/Quality Control

The Quantum Spatial Production Team members utilize many techniques in its QA/QC process. The first of these steps begins with qualified personnel. Our Team's standard orthophoto QA/QC protocols will comply with standard structural, visual, and positional accuracy evaluation criteria. These protocols will include the following validation checks:

- Structural Validation
    - Proper media formatting, data organization, file naming conventions, delivery formats, ground resolution, geographic coverage;
    - Proper data and header structure to include band definition, pixel size/definition, georeferencing, unit of measurement, and datum;
    - Proper tiling schema, compression ratios, and presence of FGDC compliant metadata.
- Visual Validation
    - Horizontal displacement/misalignment along tiles edges and seam lines within established Commission acceptance criteria thresholds;
    - Good tonal balancing across and between delivery blocks as well as between deliverables with differing resolutions;
    - Image blemishes and artifacts within Commission acceptance criteria thresholds;
    - Image appearance, smearing, and warping are within Commission acceptance criteria thresholds;
    - General compliance with our standard seam line placement techniques.
- Positional Validation: 0.25-ft, 0.5-ft, and 1-ft GSD orthophoto deliverables:
    - Computed RMSEr of 2.828-ft when tested using NSSDA testing guidelines;
    - Computed NSSDA accuracy (20+ points) such that 95% of the points tested shall meet the criteria of 5.000-ft;
    - Mismatch of features along mosaic lines and production block boundaries of equal scale such that they are equal to or less than two pixels at 95% on well-defined features (roads, sidewalk, curbs) for mosaic lines;

Positional Validation Quality Control

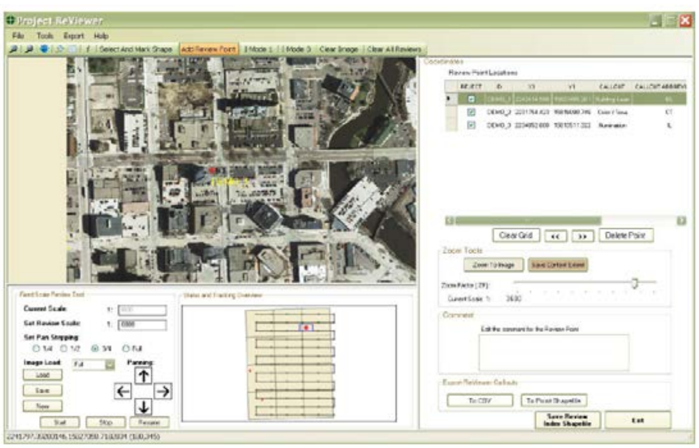


Figure 33: Accuracy Analyst™

The Quantum Spatial production Team utilizes Accuracy Analyst™ (see Figure 33) to support positional validation of orthophotography. The program is employed to verify checkpoints for all orthophotography imagery produced by Quantum Spatial. Accuracy Analyst consists of four modules that improve the efficiency and accuracy of the entire quality control process. These modules include the following:

- **CheckPoint Planner:** Enables QC staff to pinpoint verification positions based on previously obtaining aerial imagery;
- **PhotoBook:** Allows reviews to quickly select and confirm photo identification points using ground-level imagery;
- **Report Generator:** Produces verification reports in multiple formats (graphically, statistically, tabular) for improved user comprehension (all generated reports are in compliance with National Standard for Spatial Data Accuracy requirements); and
- **ReViewer:** Acts as a comprehensive quality control tool and provides a vehicle for reviewer/end user interaction. This will ultimately improve the effectiveness and timing of orthophoto submission, review, feedback, and approval.

This application has proven to be successful in expediting the quality control process for many of Quantum Spatial's statewide orthophoto projects including Wisconsin, Illinois, North Carolina, Kentucky, New Jersey, and Connecticut and will be used to support the Commission's 2015 Orthophotography Project.

14. QUALITY ASSURANCE

The Quantum Spatial quality management plan will establish the methods for ensuring a high-quality product that conforms to the specifications and is fit for use by Commission meeting their expectations. The quality management plan will capture the associated workflows, tools, techniques, and methods for reviewing and identifying defects in all deliverables as well as tracking those defects through to resolution. Quantum Spatial will establish and communicate a standard methodology for reporting and tracking issues that will be used by all stakeholders in the quality review process.

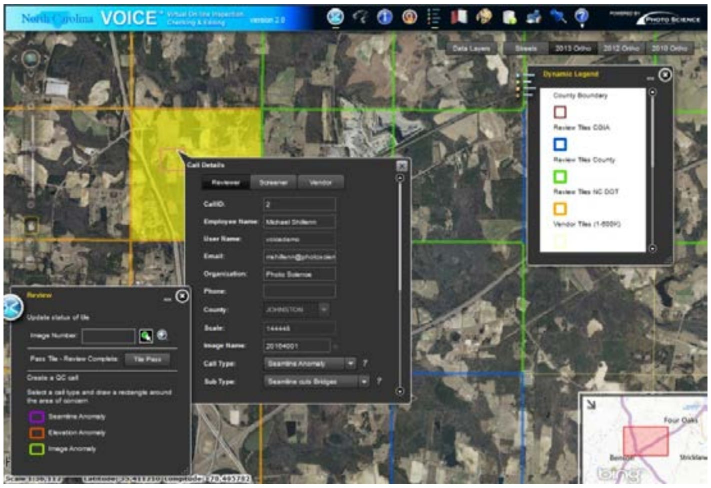


Figure 34: Quantum Spatial VOICE

The QC Team will leverage Quantum Spatial's VOICE (Virtual Online Inspection, Checking & Editing) (see Figure 34) online reviewer application to standardize the quality review process for all stakeholders. This web application provides an easy-to-use interface for reviewing the orthophotography providing the identification and tracking of defects within the deliverables. The application will serve as a streamlined method for online deployment of the digital orthophotography provided via the internet for all approved stakeholders to participate in the QC review process. Early in the project, the Quantum Spatial Team will obtain a list of key staff from Commission and other stakeholders that will participate in the quality review of the deliverables. The Quantum Spatial Team will set up each of the participants with a username and password that can be used to securely log into the VOICE online application.

15. METADATA & REPORTS

The Quantum Spatial Team will prepare, validate, and deliver metadata compliant with the Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Metadata in the required extensible markup language (.xml) format. The metadata files will be provided at the product level for each product including imagery, flight data, AT, DEM, orthophoto datasets and any optional datasets. Commission will provide metadata examples from previous project cycles to be used as templates. In general, the following metadata content will be included in the FGDC metadata deliverables. Metadata will include details for the following sections, at a minimum:

- Identification information
- Data quality information (including quantitative assessments by Commission) and must include all process steps.
- Spatial data organization information
- Spatial reference information
- Entity and attribute information
- Metadata reference information

All metadata deliverables will be complete and validated by being processed through the USGS or other authoritative Meta Parser tool without error. Metadata may also be supplemented with projects reports where the report conveys additional information not suitable for metadata.

Communication

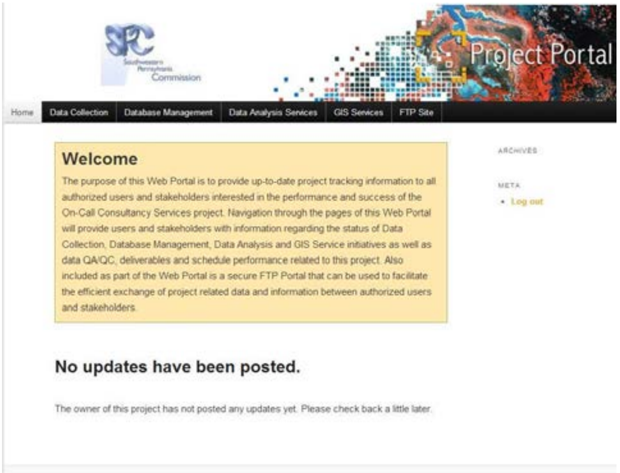


Figure 35: Quantum Spatial Project Management portal

We think it is critically important to maintain clear and timely communication with the Commission throughout the life of this project. This is critically important during the acquisition phase while we are flying aircraft in carefully designed patterns immediately over your facilities. In the post 911 world, it is very much to the benefit of Quantum Spatial and the Commission for you to understand the general locations of our planned acquisitions throughout the actual acquisition phase. We have worked many planning agencies throughout the country on acquisitions at similar altitudes and developed effective ways of communicating our plans. This allows critical personnel within the office and field environment of your organization to understand our acquisition plans. Of course our flight planners, pilots, and sensor operators are very familiar with working with the FAA, air traffic control centers, and the military to gain access to restricted airspace and maintain the communications necessary to ensure a safe and timely acquisition.

To facilitate online communication and collaboration between all stakeholders and staff for the 2015 Orthophotography Project, Quantum Spatial proposes using our online project portal. The portal will allow any authorized individuals to follow progress, provide feedback, and track project documentation and issues. Our project portals provide simple, secure online access to project documentation, Gantt charts, status reports, progress maps, and deliverables. All relevant project news and issues will be posted on the project portal for increased visibility and action. Portal users will be notified when new issues are posted and can respond or comment right on the portal making sure all involved are informed in a timely fashion. Additional details related to the Quantum Spatial project portal can be found in the Program Management section of this response.

5. SCHEDULE

Due in part to the following bulleted items, Quantum Spatial has the ability to accurately monitor and ascertain the local weather conditions, react quickly to spring windows of potential acquisition opportunities, and customize a deliver solution of any selected Geospatial services ultimately selected by the Commission or its constituents:

- Local base of operations to the seven county regional project area
- 24 aircraft potentially available for assignment
- Unmatched cross-section of digital sensors
- Previous experience with Commission Staff and program requirements
- Newest technological innovations available within the Geospatial community
- 24 hour per day production capability
- Staff of over 500 Professional Geospatial-Wisconsin Taxpaying personnel
- Desire to continue our 34 year relationship with the Commission

6. PROJECT MANAGEMENT APPROACH

Quantum Spatial will provide overall project management activities associated with each phase/task included throughout the project (see Figure 36). All activities associated with this project will be directed and executed by Jeff Stroub, CP, PLS, PPS, SP. Jeff has 40 years of overall experience in the photogrammetric mapping, remote sensing and GIS profession. The majority of this experience relates to project management experience in statewide photogrammetric mapping, orthophotography, and LiDAR programs. Jeff understands the importance of communication and active project management. Jeff and Quantum Spatial's staff have managed concurrent projects of similar nature and scope; provided project oversight and direction for internal staff supporting orthophotography, LiDAR, and planimetric data collection efforts.

Figure 36: Quantum Spatial Project Management Expertise
Demonstrated Project Management Experience: Quantum Spatial's project management Team is lead by a seasoned professional and Certified Photogrammetrist with over 30 years of overall mapping experience with specific, recent, orthophoto and LiDAR experience managing programs in Wisconsin and throughout the nation.
Comprehensive Project Management Planning: Includes risk, quality, and schedule elements that provide the keys to success.
Leverage of Microsoft SharePoint: Provided a common repository where project information can be stored and accessed by all project participants.
Experience: Proficient in managing concurrent projects of similar nature and scope; providing project oversight and direction for subcontractors supporting for orthophotography, LiDAR, and planimetric data collection efforts; and processing projects.

1. METHODOLOGIES

Quantum Spatial's approach to project management embraces many of the methodologies promulgated by the Project Management Institute (PMI) and dictates a standard project management methodology for all projects. Quality management takes place in all process groups including: initiation, planning, execution, monitoring and controlling, and closing (see Figure 37). This methodology defines standard processes that enable the Quantum Spatial Team to consistently deliver successful projects.

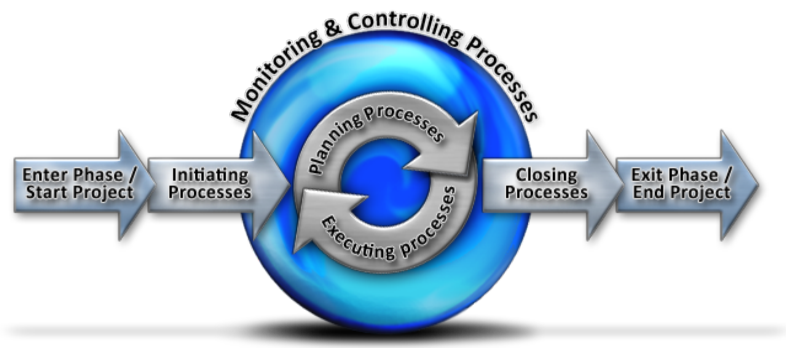


Figure 37: Quantum Spatial's Monitoring and Control Process

The project management function will manage and coordinate the planning efforts for data and control acquisition. Our assigned project manager, Jeff Stroub, CP, PLS, PPS, SP will also oversee and verify the production processes and quality controls used by Quantum Spatial production teams associated with data collection, processing, delivery of imagery, and QA/QC. This comprehensive oversight and control of the project from initiation through closeout will result in delivery of high-quality products within the schedule/budget and meeting the specifications.

2. PROJECT COMMUNICATIONS

We will establish a communications plan to identify the key stakeholders and the required communications throughout the lifecycle of the project. In addition to the methods of communication, the communication plan will establish protocols for documenting project communications, the frequency of communications, and the processes for reporting project status. Quantum Spatial believes in frequent, effective communications. Jeff and/or the discipline managers are well known to respond to Commission emails and phone calls within one business day. The communication plan will include the names and contact information for all key stakeholders and Commission representatives as well as the Quantum Spatial Team. This document will be published to the project SharePoint site for reference throughout the project.

3. PROJECT STATUS REPORTING

Jeff in conjunction with all team members will compile and issue a weekly status report to Commission representatives. Throughout the last several years Quantum Spatial has been utilizing web-based project management technology to manage and track work production tasks within a multi-disciplined project structure. The team feels a project of this nature would suit itself very well to the benefits afforded by such a project management tool. Therefore the team proposes to utilize a project portal to facilitate online communication and collaboration between all stakeholders and staff. The portal will allow any authorized individuals to follow progress, provide feedback, and track project documentation and issues. Our project portals (Figure 38) provide simple, secure online access to project documentation, Gantt charts, status reports, progress maps, and deliverables. All relevant project news and issues will be posted on the project portal for increased visibility and action. Portal users will be notified when new issues are posted and can respond or comment right on the portal making sure all involved are informed in a timely fashion.

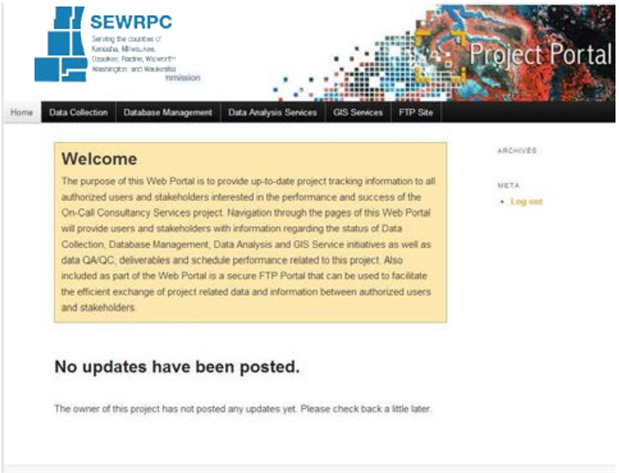


Figure 38: Quantum Spatial Project Management portal

4. PROJECT MANAGEMENT PLAN

We will build a comprehensive project management plan, which will include the following the Project Management Institute (PMI) recommended documents:

- Project scope definition
- Communications plan
- Work breakdown structure (WBS)
- Schedule management plan (Microsoft Project schedule)

- Risk management plan
- Quality management plan

We will draft the project management plan documentation and will distribute to the entire project Team. This documentation will serve as the project manager's overall plan for conducting and completing the project. During the pre-flight initiation meeting, the project management plan will be reviewed and discussed with Commission representatives. This plan will include a detailed project schedule, which will be updated on a weekly basis for tracking progress (percent complete) and due dates for milestones and tasks. All documentation included in the project management plan will be "living" documents that will be actively maintained and updated throughout the lifecycle of the project and will be delivered to the Commission as final project documentation.

Risk Management

If requested, a risk management plan could be developed to identify potential risks that might impact the implementation of the project. Each risk could be identified and documented with a unique risk identifier as well as a risk description, trigger, and probability. Through communication with the Commission, we could develop the initial risk management plan to establish strategies to manage the risks, including mitigation, acceptance, transference, or avoidance. We would only attempt to develop mitigation strategies for risks that have a high probability of occurrence and a significant impact. The risk management plan could be updated continuously throughout the lifecycle of the project as new risks are identified or risk events occur. The intent of utilizing a risk management plan is to be aware of the potential risks and address risks, where necessary, to help ensure a successful implementation. This proactive strategy to identifying potential issues could minimize the impact and effect of risk events on the schedule and/or quality.

Quality Management

Quantum Spatial Team utilizes a mature quality management plan including both a series quality assurance plan and quality control procedures. Our quality assurance plan is compatible with ISO 9001:2008 standards. Our assigned QA/QC Manager, Mike Emanuel, GISP, will be responsible for ensuring all quality procedures are followed by all Team members as well as the verification of deliverables for completeness, accuracy, and compliance to the specifications as a result of the independent quality assurance and quality control verifications.

Quantum Spatial's quality management plan will establish the methods for ensuring a high-quality product that conforms to the specifications and is fit for use by Commission meeting their expectations. The quality management plan will capture the associated workflows, tools, techniques, and methods for reviewing and identifying defects in all deliverables as well as tracking those defects through to resolution. Jeff in collaboration with Mike will direct the development of the quality management plan and will ensure that all methods employed directly assess the quality of the products as compared to the acceptance criteria. The Team will utilize Quantum Spatial's VOICE online orthophoto review application (see Figure 39) to standardize the quality review process for all stakeholders. This web application provides an easy-to-use interface for reviewing the orthophotography providing the identification and tracking of defects within the deliverables.

Figure 39: Quantum Spatial VOICE

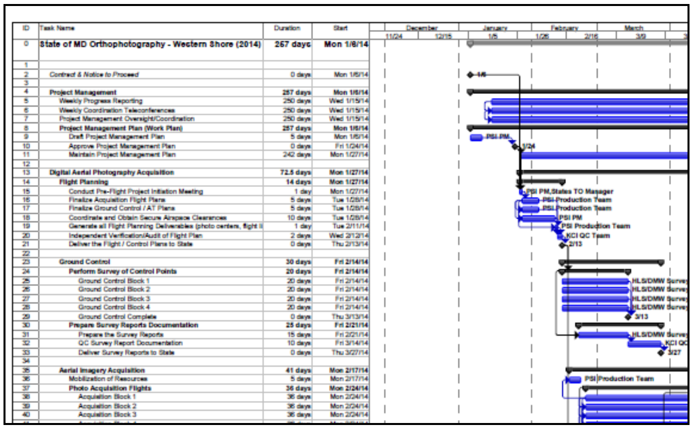


Figure 40: Schedule

Schedule Management

We would develop a detailed schedule (see Figure 40). The Microsoft Project schedule will include all task definitions, along with estimated durations and start/end dates for the tasks. Most importantly, the schedule will identify predecessors for tasks and would clearly delineate task responsibilities between all project Team members. The schedule will be actively managed throughout the lifecycle of the project with percent complete and start and completion dates. The Gantt chart will illustrate the duration of the activities as well as the relationships between tasks to help the Team members and Commission representatives clearly identify how the project activities will be conducted. Through actively managing the schedule, the project manager will be aware of any delay in progress and can work with the project Team to identify corrective action to resolve the issue.

In conclusion we hope this proposal has demonstrated our extensive previous history of Geospatial Service performance to the Commission, as well as defined the new digital instruments we own and processes we plan to implement in conjunction with the 2015 Orthophotophography Project.

Most importantly, the Wisconsin based taxpaying staff with whom you are familiar, located in our Sheboygan Corporate headquarters are anxious to continue our provision of Professional Geospatial services for the Commission and its constituents!

If we may answer any questions related to this offering, please contact me at your convenience.

Sincerely,

Quantum Spatial, Inc.

Jeffrey B. Stroub

Jeffrey B. Stroub, CP, RLS, PPS, SP
Vice-President Business Development

Patrick M. Olson

Patrick M. Olson, CP, PE, PLS
President / CEO

7. COST PROPOSAL

1. DIGITAL ORTHOPHOTOGRAPHY

a. Provide cost proposal for 12-inch resolution orthophotography for entire 2,967-square mile project area and for each individual county and out-of-region area as listed above.

County/Area	12-inch Ortho Cost
Kenosha	$ 13,066
Milwaukee	$ 11,374
Ozaukee	$ 11,045
Racine	$ 15,980
Walworth	$ 27,072
Washington	$ 20,445
Waukesha	$ 27,260
Out-of-Region Area	$ 12,643
Total Area	$ 138,885

b. Provide cost proposal for 6-inch resolution orthophotography for entire 2,967-square mile project area and for each individual county and out-of-region area as listed above.

County/Area	6-inch Ortho Cost
Kenosha	$ 20,020
Milwaukee	$ 17,425
Ozaukee	$ 16,850
Racine	$ 24,480
Walworth	$ 41,620
Washington	$ 31,395
Waukesha	$ 41,835
Out-of-Region Area	$ 19,375
Total Area	$ 213,000

a. Provide cost proposal for 3-inch resolution orthophotography for Kenosha County area only.

County/Area	3-inch Ortho Cost
Kenosha	$ 82,844

b. Provide cost proposals for alternative resolutions (e.g. between 12-inch and 3-inch resolution) and appropriate scales of digital orthophotography for each individual county as listed above, if such alternatives are offered or recommended by your firm.

County	Alternative Resolution Costs (NUMBER OF PRODUCTS TO BE DETERMINED BY VENDOR)		
Kenosha	See note below		
Milwaukee			
Ozaukee			
Racine			
Walworth			
Washington			
Waukesha			

The nature of the direct native pixel capture from our digital imagery sensors offers a virtual infinite array of pixel ground sample distances (GSD) and color variations to our clientele. The variations available are based upon the planned altitude of the sensors. The GSD's indicated above (.25', .5' and 1.0') are considered industry standard. We would be happy to discuss and provide additional fee estimates for any custom variation of GSD's and color combinations as may be requested.

2. DIGITAL OBLIQUE PHOTOGRAPHY

a. More specifically, provide cost proposals for each resolution of oblique photography for each county as listed above. Do not provide cost proposal for entire 2,967-square mile project area, and do not provide cost proposal for out-of-region area.

County	12-inch	6-inch	3-inch
Kenosha	$ 29,746	$ 45,592	$69,778
Milwaukee	$ 25,894	$ 39,688	[redacted]
Ozaukee	$ 25,252	$ 38,704	

Racine	$ 36,380	$ 55,760	[redacted]
Walworth	$ 61,632	$ 94,464	[redacted]
Washington	$ 46,652	$ 71,504	[redacted]
Waukesha	$62,167	$95,284	[redacted]

3. LIDAR DATA

a. More specifically, provide cost proposals for each point spacing of LiDAR data for each county as listed above. Do not provide cost proposal for entire 2,967-square mile project area, and do not provide cost proposal for out-of-region area.

County	1.0-meter Spacing	0.7-meter Spacing
Kenosha	$ 23,310	$ 29,885
Milwaukee	$ 20,291	$ 26,015
Ozaukee	$ 19,621	$ 25,155
Racine	$ 28,509	$ 36,550
Walworth	$ 48,465	$ 62,135
Washington	$ 36,559	$ 46,870
Waukesha	$ 48,716	$ 62,458

4. DIGITAL TERRAIN MODEL FILES

a. More specifically, provide cost proposals for the two different accuracies of DTM files for each county as listed above. Do not provide cost proposal for entire 2,967-square mile project area, and do not provide cost proposal for the out-of-region area.

County	200-scale DTM Cost	100-scale DTM Cost
Kenosha	$ 30,900	$ 39,615
Milwaukee	$ 26,899	$ 34,485
Ozaukee	$ 26,009	$ 33,315
Racine	$ 37,791	$ 48,450
Walworth	$ 64,245	$ 82,365
Washington	$ 48,461	$ 62,130
Waukesha	$ 64,579	$ 82,792

5. CONTOUR LINE FILES

a. More specifically, provide cost proposals for the two different accuracies and two different feature sets of contour line files for each county as listed above. There will be four costs per county: 1) 200-scale without text; 2) 200-scale with text; 3) 100-scale without text; and 4) 100-scale with text. Do not provide cost proposal for entire 2,967-square mile project area, and do not provide cost proposal for the out-of-region area.

County	200-scale Without Text	200-scale With Text	100-scale Without Test	100-scale With Text
Kenosha	$ 2,121	$ 2,121	$2,117	$ 2,117
Milwaukee	$ 1,846	$ 1,846	$ 1,843	$ 1,843
Ozaukee	$ 1,785	$ 1,785	$ 1,782	$ 1,782
Racine	$ 2,594	$ 2,594	$ 2,589	$ 2,589
Walworth	$ 4,410	$ 4,410	$ 4,410	$ 4,410
Washington	$ 3,327	$ 3,327	$ 3,321	$ 3,321
Waukesha	$ 4,433	$ 4,433	$ 4,425	$ 4,425

6. OTHER PRODUCTS

b. Provide cost proposals for the additional products for each county as listed above. Do not provide cost proposal for entire 2,967-square mile project area, and do not provide cost proposal for the out-of-region area.

County	Other Product Costs (NUMBER OF PRODUCTS TO BE DETERMINED BY VENDOR)		
Kenosha	See note below		
Milwaukee			
Ozaukee			
Racine			
Walworth			
Washington			
Waukesha			

The services provided from a true Geospatial Professional firm are designed based upon the scope of services sought by the client. Following a detailed discussion pertaining to the desires of a client, the Professional applies the appropriate technology solution to meet the client's expectations, accuracy requirements an budget. Thus every project undertaken by Quantum Spatial, Inc. is custom designed to a client's unique specification. Quantum Spatial, Inc. owns and operates every type of geospatial imagery (aerial & ground), and terrain processing.

8. APPENDIX B: CAMERA CALIBRATION REPORT

The following pages contain a calibration report of the UltraCam Eagle Quantum Spatial will use for this project. The report was completed July 16, 2012.