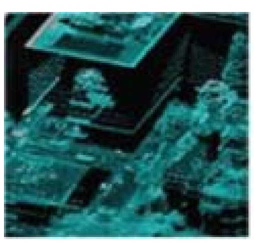
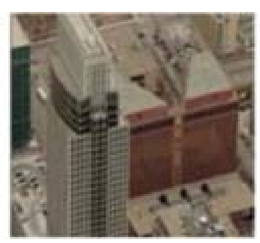
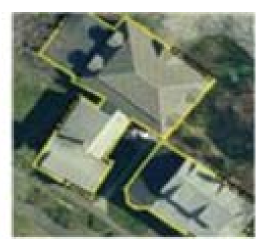
RFP for 2015 Regional Orthophotography Project

April 25, 2014

Prepared for
Southeastern Wisconsin Regional Planning Commission







Submitted by:
Dean Larson
Wisconsin District Manager
Pictometry International Corp.
(612) 201-1846

PICTOMETRY® INTELLIGENT IMAGES

April 25, 2014

Southeastern Wisconsin Regional Planning Commission (SEWRPC)
P.O. Box 1607
Waukesha, WI 53187-1607

Re: RFP for 2015 Regional Orthophotography Project

Dear SEWRPC:

Pictometry is proud to submit its response to SEWRPC's Request for Proposals for 2015 Regional Orthophotography Project. Pictometry has spent millions finessing its high accuracy AccuPlus orthos and orthomosaics. We stand by the fact that our oblique images are superior to any in the marketplace today and the software tools provided through EFS and our new Connect cloud-based image portal are unparalleled in the industry. We are the only company that has created hundreds of interfaces and integrations with our Esri, CAD, CAMA, E-911, Street View, Law Enforcement, and other mainstream GIS partners so that our imagery and tools can be used seamlessly within them. As well, we provide an unmatched dedication to customer service and technical support, with both a District Manager and Regional Technical Manager who live near and support the State of Wisconsin.

Highlights of this offering include:

- High quality orthogonal and oblique imagery for the entire SEWRPC area noted, with 9-, 6- and 3-inch GSDs captured in the three regions specified, as well as LiDAR, where needed
- The most advanced system for deployment of digital aerial oblique and orthogonal imagery in the world
- *Access to existing imagery from all seven county members in SEWRPC as well as in surrounding counties (i.e. Jefferson, Rock, Sheboygan, Fond du Lac and Dodge Counties)*
- Access to new emerging technologies, including Pictometry Connect
- *The only vendor whose imagery and tools have been interfaced/integrated with many of the CAD, CAMA and GIS software systems used by various SEWRPC members. These include long-standing integrations with Vision Appraisal and Tyler's Univers CAMA software applications (Waukesha, Wauwatosa and Mequon), Latitude Graphics and Esri ArcServer (Milwaukee and Waukesha) and Intrado for 911 (Washington and Walworth).*
- Imagery captured with Pictometry's third generation PentaView digital sensor system which will enable data acquisition and production to proceed at an unprecedented rate
- *The ability to create a cooperative agreement with Pictometry so that other participating counties can purchase Pictometry products at the same rates and discounts noted herein*
- Imagery captured with Pictometry's third generation PentaView digital sensor system which will enable data acquisition and production to proceed at an unprecedented rate

We look forward to working on and successfully delivering this project to SEWRPC.

Respectfully Submitted,

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Historical Background

Since inventing geo-referenced aerial oblique imaging in 2000, Pictometry International Corp. has redefined the global standard for visual-centric data analytics, integration, and reporting. Professionals across government agencies and commercial market segments use Pictometry's patented technologies daily, overlaying GIS data on images and integrating existing systems to enhance productivity, gain unique insights, and change lives. With over 35 million images added annually to its cloud-accessible servers, the Pictometry's unparalleled library now contains more than 230 million images–each mapped to the individual pixel.

Pictometry is the largest aerial imaging company in the United States, with 258 employees, including a staff of licensed surveyors, photogrammetrists, LiDAR analysts, engineers, processors, project managers, software engineers, and an experienced management team. With seventy-four airplanes in Pictometry's North American fleet, Pictometry has the capacity and systems available to handle the SEWRPC's needs in a timely, efficient manner.

Based in Rochester, NY, all of Pictometry's imagery processing and production work is done within the boundaries of the United States. The state-of-the-art cameras, lenses and calibration systems Pictometry has developed allows for the capture of metric oblique and orthogonal geo-referenced images which its clients use for authoritative purposes.

Pictometry's patented imaging process has captured geo-referenced, high-resolution oblique and nadir images for thousands of county, state, federal, and commercial customers. Pictometry's metric oblique images offer the unique ability of being fully geo-referenced and measureable without distorting the natural perspective captured in the oblique images. Pictometry is also a software company, creating a wide range of applications to access, view, and exploit the oblique and nadir imagery. These solutions include both desktop solutions, such as Pictometry's Electronic Field Study (EFS), as well as web-based solutions, such as Pictometry Connect and Pictometry's Server Edition. Pictometry provides numerous applets, plug-ins, and API's in order to embed Pictometry solutions inside existing software environments. This allows the user to gain the benefits of Intelligent Images® while still having access to the wealth of data they have already accumulated in their current environment.

Pictometry's experienced, professional staff includes the very pioneers who developed this technology and created the process to capture and deliver metric oblique and orthogonal aerial imagery. Among the staff are three ASPRS Certified Photogrammetrists and Professional Surveyors licensed in 22 states. Pictometry's world- leading fleet of aircraft has allowed Pictometry to acquire extensive experience managing multiple

Pictometry International Corp.

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Year Established: 1994. Incorporated in State of Delaware 11/2/2000

DUNS#: **967973769**
GSA#: **GS-35F-0801N**
FEIN#: **16-1595473**

Corporate Officers:
CEO/President: Chris S. Barrow
Secretary/Treasurer: John R. Polchin
Vice President: Linda K. Salpini

Official Company Signatory:
Senior VP, Finance: Linda K. Salpini

Key Personnel:
Stephen L. Schultz
Chief Technology Officer

Charles Mondello
Deputy Chief Technology Officer

ASPRS Certified Photogrammetrists:

Michael J. Zoltek, CP, LS, CFedS, GISP,
VP of Surveying and Mapping Certificate #1523
State Licensed Surveyor and Mapper in 19 U.S. states and the US Virgin Islands (including Wisconsin)

Thom S. Salter, CP, PSM, SP,
Director of Photogrammetric Production
Certificate #1525
Virginia Licensed Surveyor Photogrammetrist #408000140.
Florida Licensed Professional Surveyor & Mapper #LS6847

Yandong Wang
Director of Photogrammetric Engineering
Certificate #1340
Over 20 years of experience

large capture projects simultaneously. Pictometry's large fleet results in resource allocation never becoming an issue for the capture of SEWRPC's imagery.

Experience

Aerial Photography

Pictometry has become the leading provider of geo-referenced aerial image libraries and related software. With over 1,195 U.S. counties as customers, and hundreds of other state, federal, and commercial collections, Pictometry has amassed imagery in all 50 states, all of the top 133 U.S. cities, and over 90% of the urbanized area census tracts. Pictometry captures this imagery with a fleet of 74 aircraft, outfitted with Pictometry's patented orthogonal/oblique capture technology, and processes this data at its Rochester-based facilities.

Orthogonal Imagery

Pictometry's experience with orthogonal imagery acquisitions is extensive and includes the acquisition of approximately 40,000,000 orthogonal image frames over just the past three years. Pictometry typically completes orthogonal imagery acquisitions for 400 customers on an annual basis. Major orthogonal imagery collections include the counties of Fargo, ND (2011), Ward-Minot, ND (2010 and for floods in 2011), Williston, ND (2012), Los Angeles County in 2003, 2004, 2006, 2008, 2010, 2011 and 2013, as well as Philadelphia (2010 and 2012), Milwaukee (2010 and 2013), Baldwin, AL (2013), Maricopa, AZ (2012), Bay County, FL (2010 and 2013), Lee County, FL (2011), Richmond, GA (2010), Sioux City, IA (2011), Mecklenburg, NC (2012 and 2013), Nye NV (2010 and 2013), Franklin, OH (2010, 2011, 2012), Charleston, SC (2012), City of Sioux Falls, SD (2012), Washington, UT (2012), Davis, UT (2011), Blacksburg, VA (2013), Eglin AFB, FL.

Federal and State Buying Programs

Pictometry has held a Federal General Services Administration (GSA) contract for ten years now in good standing under Contract #GS-35F-0801N. It is also an approved vendor under the State of NY Office of General Services, State of Ohio Department of Administrative Services, State of Oregon and the State of Florida Department of Revenue.

Financial Stability

Since incorporation in 2000, Pictometry's growth has been wisely planned and accomplished well within its fiscal means. The recent merger with EagleView, a stable and fast growing company in the report generation business, was a cashless merger of equals primarily for vertical market reasons – EagleView generates the majority of their reports from data extracted directly from Pictometry imagery. This merger allows greater access to that data and facilitates a number of cost savings company-wide. The combined company revenues are greater than $100 million per year. Over $5 million is invested annually in Research and Development of new and updated technologies, including an upgrade of the entire capture system fleet in 2012. A copy of bank information and trade references are available upon request.

Detailed Technical Approach

Pictometry Project Management

The past experience of the Pictometry Team in the successful preparation, flight, delivery and implementation of large scale orthogonal and oblique imagery projects is unparalleled in the industry. Ms. Katie Neal-Vacca will again be assuming the responsibilities of Project Manager.

Ms. Neal-Vacca will supervise all aspects of the project with constant communication with the client and any subcontractors to ensure seamless, successful, and on-time delivery of all portions of the project. All production support for the SE Wisconsin RPC project will report directly to Ms. Neal-Vacca and she will have full control of the resources to ensure that the project moves forward on schedule.

Project & Contract Preparation

Pictometry considers communication of the utmost importance throughout a project's life cycle. This communication begins at Project and Contract Preparation, at which point Pictometry's experienced sales team and contracts department, as well as the Project Manager, will discuss desired outcomes and deliverables with the client to ensure that all requirements are fulfilled with the contracted deliverables. A key element to this process is Pictometry's use of SalesForce.com for accurate selection of deliverables as well as Microsoft Access for project tracking purposes.

Kick-off Meeting

In continuation of consistent communication, shortly following a contract award, Pictometry will be available for a Kickoff Meeting with any interested participants. This meeting will include the client and possibly subcontractors for the project. The intent of this meeting is as follows:

- Discuss and schedule a timeframe for weekly meetings
- Review of the RFP deliverables against Contract Preparation to ensure all required contract deliverables are properly accounted for
- Technical discussion regarding requirements of each deliverable for the client compared to expectations of Pictometry to ensure consistency
- Review of the flight plans
- Discussion of flight capture process
- Step-by-step discussion of the acquisition plan, including resource allocation across the project area set forth in the RFP
- Review of quality control process which takes place at Pictometry during and after flight completion, including re-flights
- Review of product specifications and acceptance procedures and criteria
- Definition of communication protocol amongst the team to ensure full information transfer to all parties involved
- Review of previous weekly reports for any adjustments required

Communication Management

Throughout the duration of the project, Pictometry will be available for weekly teleconference meetings for interested parties. Each meeting will be followed up by a weekly report (please see example below). This approach is recommended for ensuring full awareness and has been successful on projects of this size in the past.

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Pictometry Weekly Status Report

Project Name: LARIAC3

Report Date: 3/5/2012

Report Number: 55

Prepared By: Katie Neal-Vacca

Current Status:

- Flight Planning: Completed
- Data Acquisition: Image Capture Complete
- Scheduled Flight Plans: Complete
- Finished Flying: All Image Capture Complete

Scheduled Work:

- Data acquisition for AT blocks #1-29
- Initial Processing starting for #1-29
- Blocks 1-29 are 100% complete

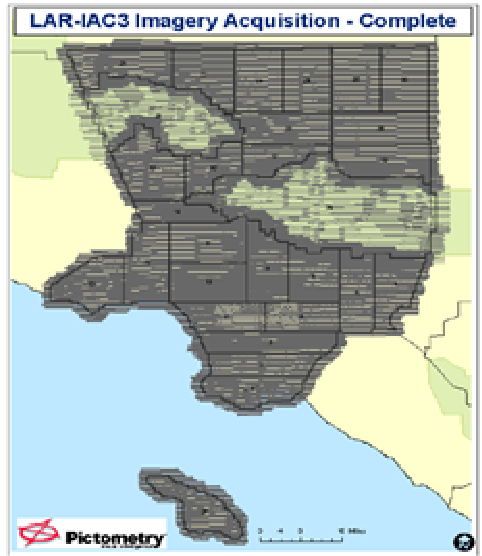
AT Blocks:

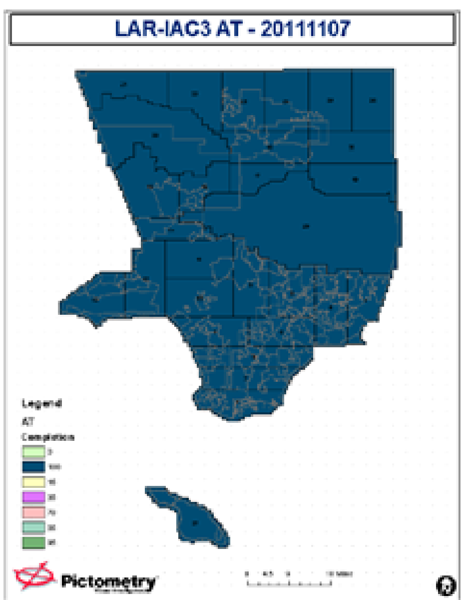
- Imagery Sent to Sanborn: 1-29
- Blocks Pending Approval from Dewberry:
- Blocks Accepted by Dewberry: 1-29

Mosaic Tile Delivery:

- Blocks sent to Dewberry: 1- 29
- Blocks reviewed by Dewberry: 1- 29
- Fixed Edits delivered to Dewberry: 1-29
- Final Approval by Dewberry: 1- 29

Imagery Acquisition Complete





Completed Schedule-

AT Block	Estimated AT Delivery Date	Updated AT Delivery Date	AT Delivery	AT Approval	Estimated Tile Delivery	Updated Tile Delivery	Final Tile Delivery	Accepted by Dewberry
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	Accepted			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	Accepted			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	Accepted			[illegible]	[illegible]		[illegible]	[illegible]
26	Accepted			[illegible]	[illegible]		[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Sample Weekly Status Report

Project Planning

Pictometry will create a functional and operational project plan in order to ensure successful and timely project completion for the SWRPC. Key aspects of this plan are the flight plans, a ground control survey plan, and an aerial triangulation plan.

The project as proposed here is based on an acquisition in spring of 2015 and the use of Pictometry's upgraded PentaView Sensor System. Following the fleet-wide upgrade to a 29MP sensor in 2012, Pictometry's Sensor System is optimized for collection of imagery at 3" – 9" GSD and no cost savings is realized through the collection of imagery at a GSD of 12". Therefore, Pictometry has proposed orthogonal and oblique collections at no coarser than 9" resolution. If a 12" orthogonal image is required, Pictometry will produce this imagery using nominally 9" source data and will also make available the full 9" GSD product.

Flight Planning

Pictometry's flight plans take into account the multiple aspects of collecting oblique and orthogonal imagery concurrently, including checks to ensure proper GSD, terrain height constraints, ATC restrictions, etc., to ensure that oblique and orthogonal images are captured at the proper ground sample distance (GSD), and ensure complete coverage of the area of interest (AOI) from all five perspectives.

Key considerations for flight planning for the project will include:

- 'Cross strip' flight lines will be planned to provide strength of figure to the upcoming bundle adjustment. These lines are planned to coincide with surveyed GCPs once locations have been finalized.
- Additional flight lines planned over downtown areas. The additional lines and waypoints are planned to minimize building lean in the final mosaic by ensuring proper perspective imagery is available.
- Flight lines along longer stretches of elevated roadways

Pictometry has created a sampling of potential flight plans based on 3-inch, 6-inch, and 9/12-inch GSD. Maps showing these sample plans are available in the Appendix. Typical flight altitude information and other information are presented in the specification chart following the Orthogonal Imagery Processing section.

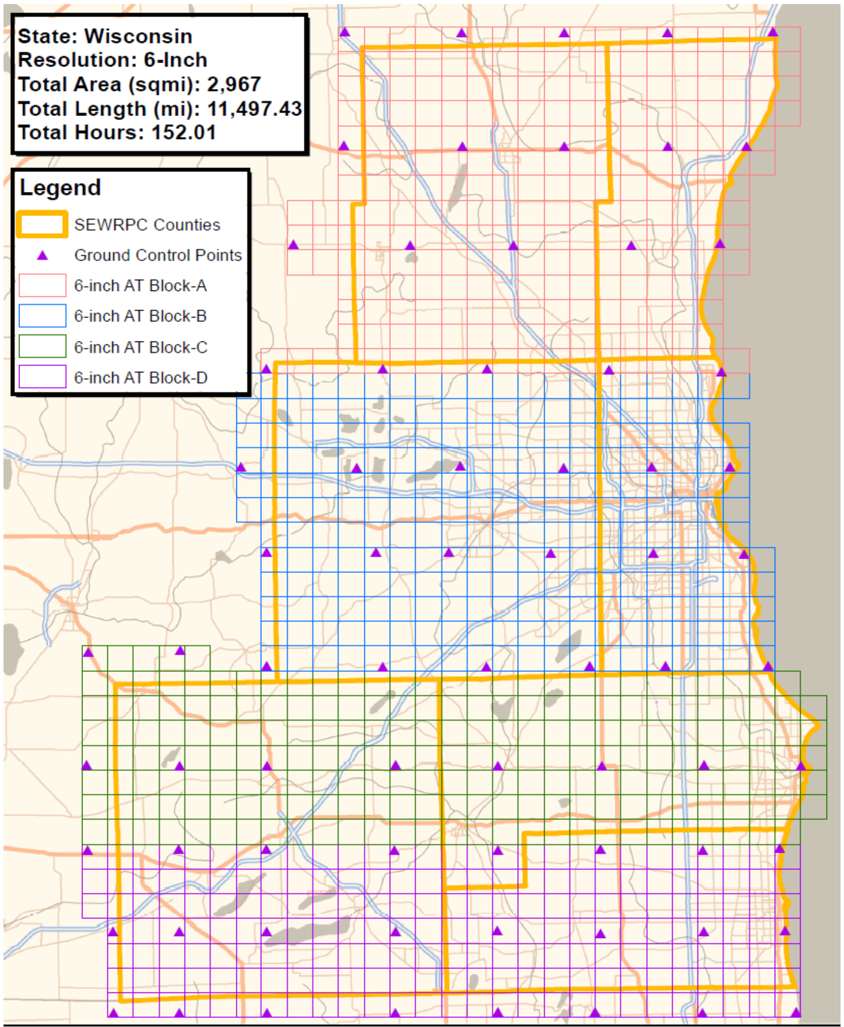
Aerial Triangulation

Developed in conjunction with the flight plans will be an aerial triangulation plan. This plan will specifically include the groupings (blocks) of imagery planned for each adjustment. The plan will indicate areas of overlap between blocks (i.e. frames to be included in multiple adjustments) to ensure a smooth and continuous transition between blocks. This plan will be prepared once the GSDs of collection have been finalized and will be presented in SHP file format as well as summarized in a series of visual presentations.

Ground Control

The ground control portion of the project plan will be prepared in conjunction with the flight plan and AT block layout. In support of the aerial triangulation portion of this project, Pictometry will contract with a licensed Wisconsin surveying firm (likely RA Smith as in previous regional projects) to provide targeting and/or surveying services. In areas where existing section corners or other monumented points are available and accessible, RA Smith will place or paint targets as appropriate to ensure visibility and measurability in the imagery. In areas where new photo control needs to be established, Pictometry will utilize artificial targets such as painted lines or placed targets as well as existing ground features with strong photo-recognizable characteristics such as sidewalk or driveway corners for photo-identifiable ground control points. In addition to the surveyed GCPs, Pictometry will utilize available NGS CORS stations as control during the POS data post-processing phase described below.

A ground control survey report with a licensed Wisconsin Surveyor's seal will be prepared upon completion of the survey to be delivered with the orthorectified imagery and/or elevation surface.



Proposed 6-inch GSD AT Block Layout

Project Plan Deliverables:

- Flight line file (SHP format)
- LiDAR Flight Plan (where applicable)
- Planned camera centers (SHP)
- Confirmed AT block Layout
- Planned GCP file
- Tentative Acquisition Schedule

Fleet

Pictometry operates a fleet of 74 aircraft domestically. The fleet comprises 60 Cessna 172 aircraft, 1 Cessna 206 aircraft, and 13 Piper Aztec aircraft. Seventy three of these aircraft are outfitted with a version of Pictometry's PentaView imaging system. The remaining aircraft is equipped with Pictometry's Optech ALTM Gemini LiDAR system. Pictometry's PentaView sensor system is described in detail below.

Camera System

Pictometry's 16-megapixel PentaView imaging system carries the *United States Geological Survey (USGS) Camera Type Certification* and comprises five custom designed cameras and an Applanix Position and Orientation System (POS) which includes both a Global Positioning System (GPS) antenna and an Inertial Measurement Unit (IMU). The five cameras are aimed with one looking nadir and four looking in each of the four cardinal oblique directions. Pictometry's 29-megapixel PentaView imaging system is constructed on the USGS approved platform and incorporates upgraded 29-megapixel sensors.

An in-depth review of Pictometry's PentaView Sensor System is available at http://calval.cr.usgs.gov/past-activities/digaerial/usgs-digital-aerial-type-certification/. The Pictometry PentaView Capture System is the only combination oblique/vertical capture system to receive Camera Type Certification from the USGS.

Pictometry's PentaView Sensor System is built off of an Illunis sensor and incorporates custom designed lenses. The system is deployed in two primary configurations. The standard configuration incorporates a 65mm lens aimed to the nadir position and four 85mm lenses one aimed at each of the four cardinal directions. An additional high altitude system incorporates a 120mm lens aimed to the nadir and four 170mm lenses, one aimed at each of the four cardinal directions.

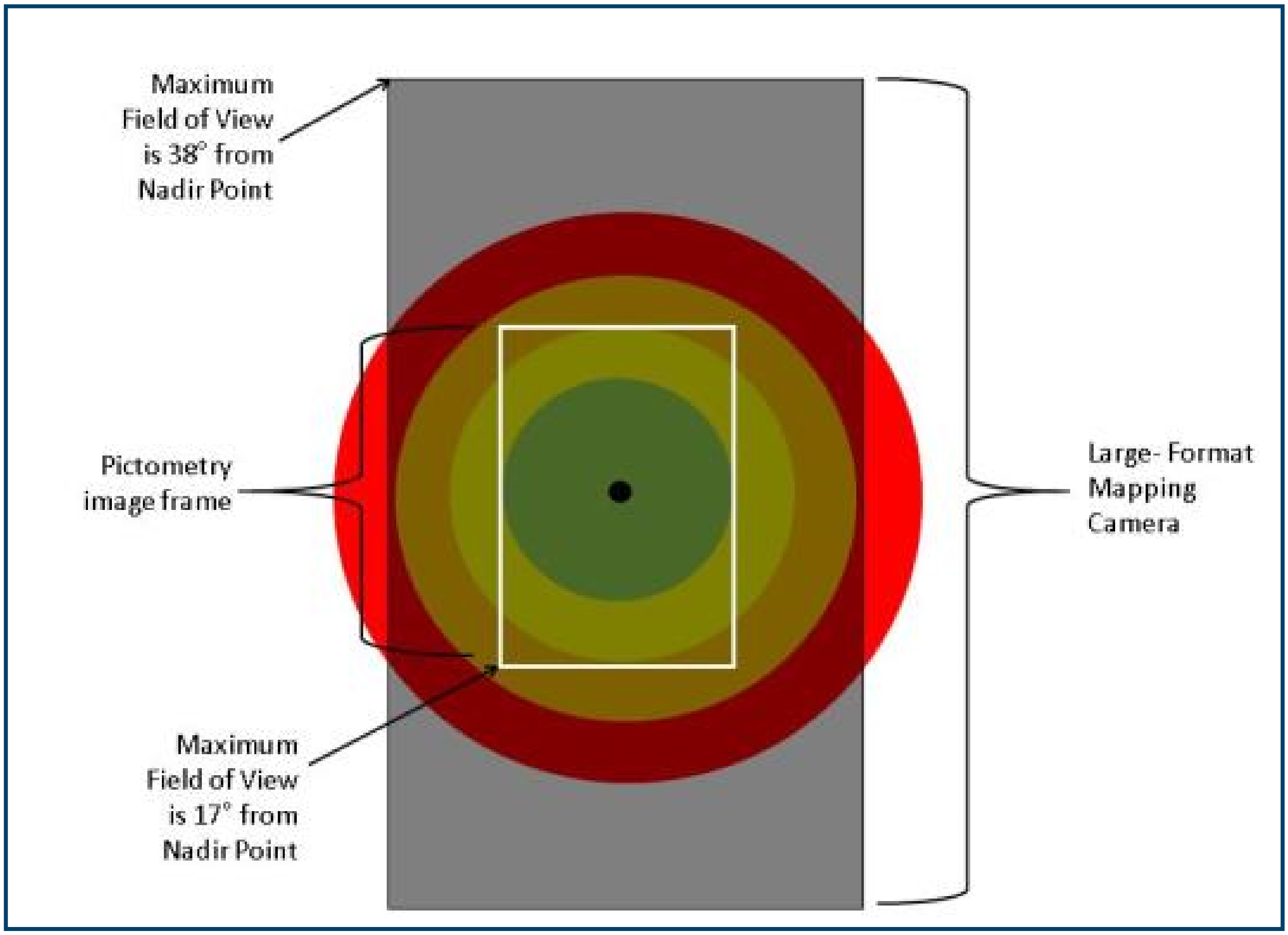
The availability of these two systems allows Pictometry to shift altitude if required to do so by ATC.

Pictometry AccuPlus Orthogonal Imagery – The Small Format Advantage

Unique to large area collections in the ortho imagery industry, Pictometry's use of a small format sensor (cross-track field of view (FOV) is +/-15°) provides for creation of ortho mosaics superior in a number of ways to those created from imagery collected with a large format camera. This section details those advantages and the related benefits provided to SE Wisconsin RPC by the use of this technology.

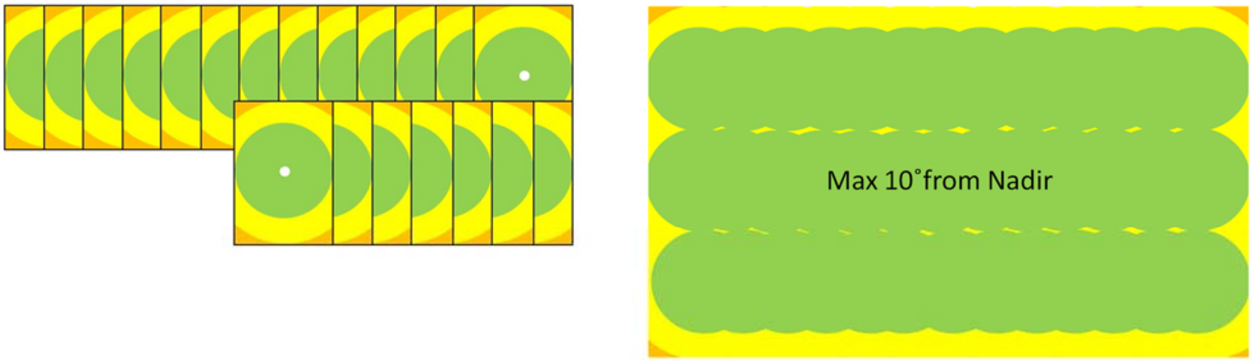
Perspective Falloff

A primary feature of Pictometry's PentaView Capture System is the small format sensor employed to collect the nadir frames subsequently used to create the ortho mosaic. Pictometry's PentaView System is defined as a small format system based on the size of the sensor utilized which, in conjunction with Pictometry's custom designed superior mapping grade lenses yields a smaller area of coverage per frame than a traditional large format mapping camera. The diagram above illustrates the difference in coverage of a single image frame captured by a Pictometry sensor as compared to a typical large format camera. The primary driver of the small format advantage is the closeness of the nadir point (black dot directly in center) to the corner of the frame of the Pictometry nadir image (outlined in white in the center) as compared with the corner of the frame of a large format image (corner of large gray polygon).



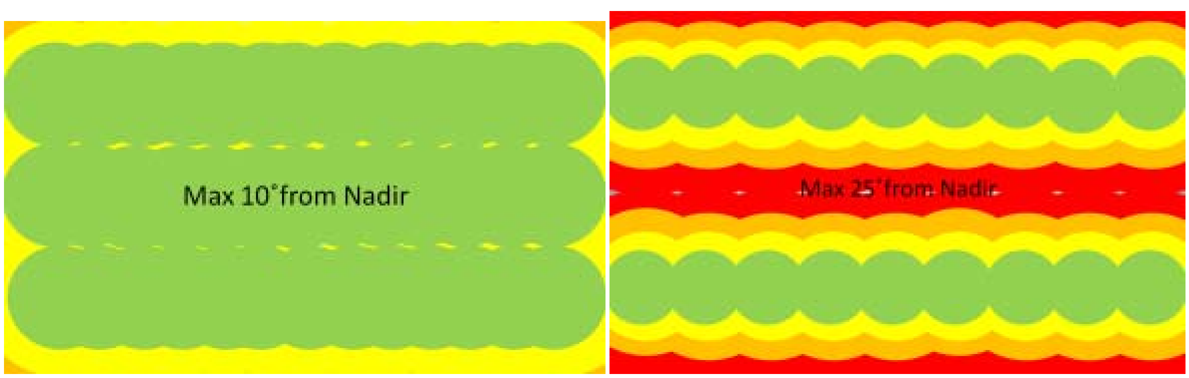
Pictometry PentaView vs. Large Format Camera

The difference is striking when individual frames are compared and manifests even more strongly when the impact of a standard 30/60 percent overlap capture is taken into account.



Effect of Mosaic Creation - Frames Create Single Image

As shown in the above diagram, when used for production of ortho mosaicked imagery, the effect of the mosaicking process is an ortho image in which the nominal maximum deviation from nadir is slightly over 10 degrees. When imagery from a typical large format camera is used to create an ortho mosaic, as shown below, the resultant mosaic includes significant areas where the source pixels were captured from a perspective nearly 25 degrees from nadir, indicated by red in the image. If a camera with an even larger field of view (some current large format capture systems extend to 55 degrees from nadir in the corner of frames) the effects is even more severe. This phenomenon is referred to as Perspective Falloff.



Pictometry PentaView Imagery (left) vs. Typical Large Format Camera

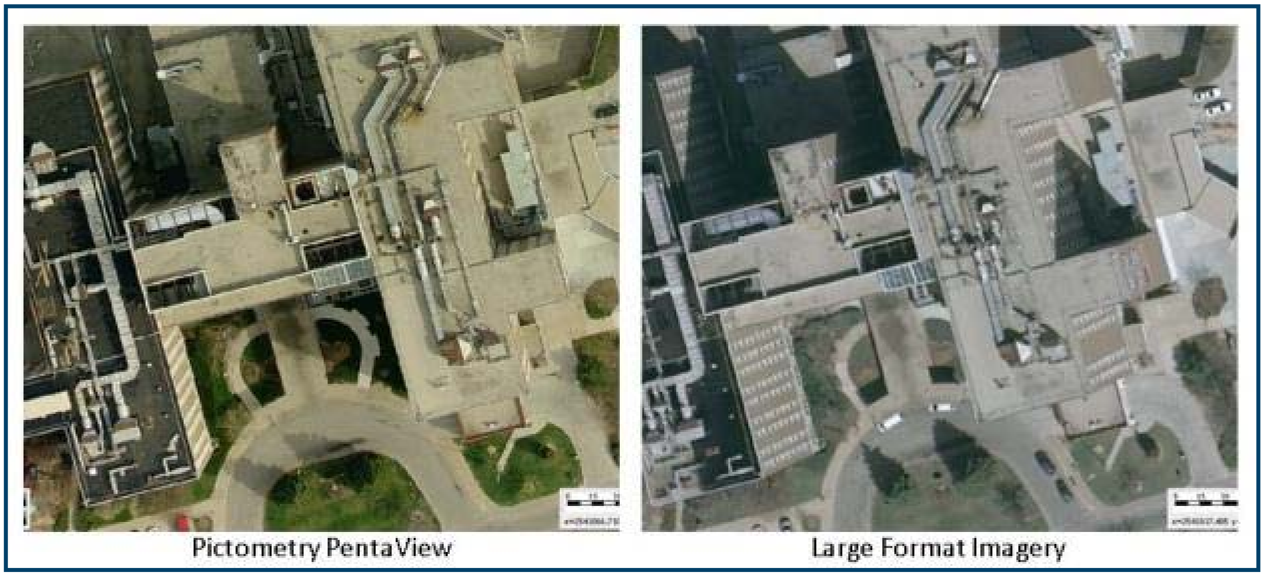
Reduced Radial Displacement

Pictometry's small format sensor produces a superior nadir perspective as compared with traditional large format mapping cameras. The narrow field of view of Pictometry's nadir camera produces an ortho mosaic in which features are viewed from a perspective that rarely exceeds 10 degrees from nadir. This results in a maximum radial displacement of elevated features such as buildings of approximately 1.6 feet per story project wide. A typical large format mapping camera mosaic will result in maximum horizontal displacement of up to 4.5 feet per story. Put simply, an area-wide mosaic captured with a large format camera has more feature lean in 71% of the area mosaicked.

Reduced Feature Occlusion

In addition to the decrease in horizontal accuracy caused by radial displacement, another effect of perspective falloff is the increasing occlusion of ground level features. The reduction in radial displacement seen in ortho mosaics created from Pictometry imagery manifests itself as reduced occlusion across the entire ortho mosaic, not only in areas featuring very tall structures.

Based on the calculation of radial displacement presented above, a typical two story house will occlude nearly 10 feet of ground space 'behind it' in an ortho mosaic created from imagery collected by a large format camera - this 10 feet of occlusion can be sufficient to conceal features as large as patios or decks, driveways, or storm cellar entrances. In these same areas, a Pictometry image will occlude at most 3.5 feet behind the house, rendering such features visible and identifiable.

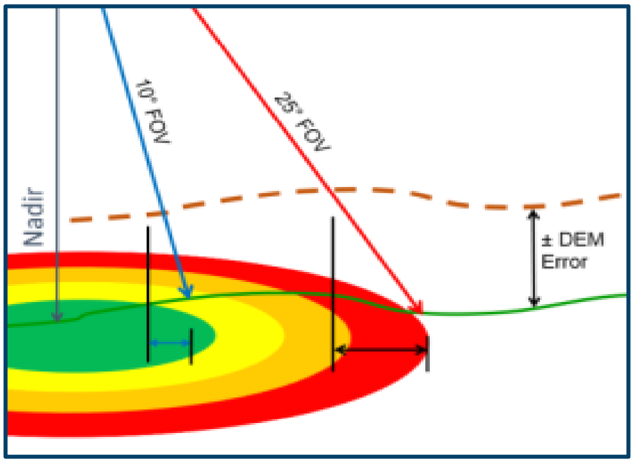


Occlusion Effects Mitigated by Use of Pictometry PentaView Sensor

The reduced perspective falloff can be emulated with a large format camera by significantly increasing the frame and line rates; however, this increase in data collection results in a significant cost increase. Pictometry's approach provides this benefit project wide.

Increased Inherent Accuracy

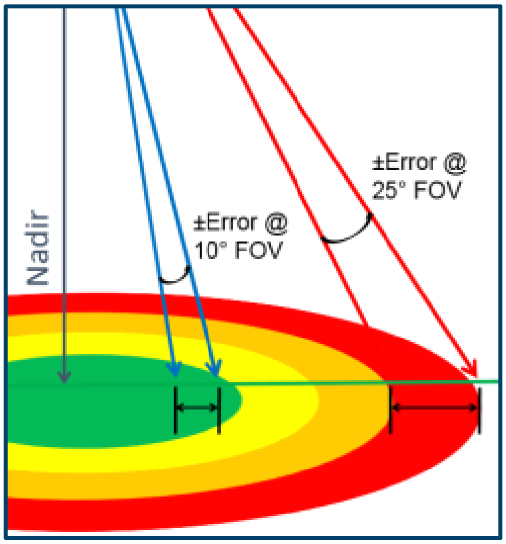
Perspective falloff is not the only effect on imagery as the angle from nadir increases. The impact of any residual uncertainty in orientation (whether from IMU or post-triangulation) and rectification surface errors increases directly as a function of distance from nadir or angle from nadir. This effect can be seen in the two following diagrams. Both effects contribute approximately 2.5 times more error at 25 degrees from nadir than at 10 degrees. It should be noted that though the term 'error' is used here, the effect is based on uncertainty inherent in any measurement.



Effect of DEM Increases with Distance from Nadir

Example: If a DEM error of 1.0 feet exists in a given location, the ortho rectification process will result in a horizontal displacement of 0.17 feet, or about one-half (½) pixel at 4 in GSD if the pixel was imaged at 10 degrees off nadir. Similarly, the ortho rectification process will result in a horizontal displacement of 0.46 feet, or about one and one-third (1⅓) pixels at 4-inch GSD, if the pixel was imaged at 25 degrees from nadir.

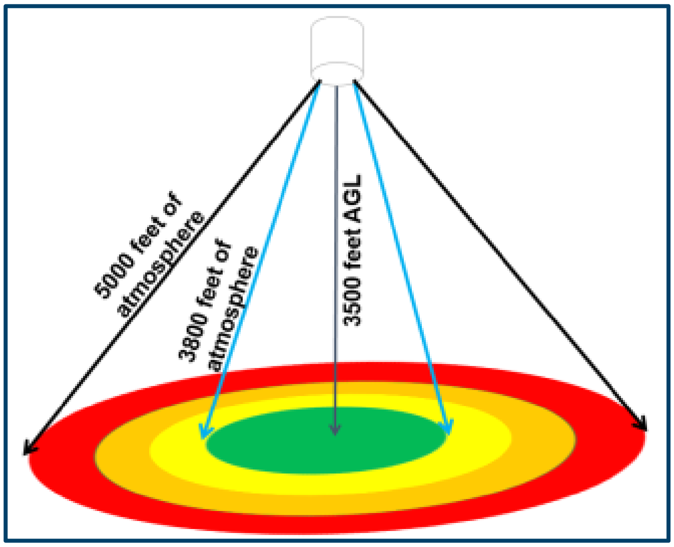
The impact of a given orientation angle error scales in the same way, increasing by a factor of 2.5 as angle from nadir increases from 10 degrees to 25 degrees.



Effect of Orientation Error Increases with Distance from Nadir

Reduced Exposure Falloff

In addition to the geometric effects caused by perspective falloff and described above, the use of a small format camera, such as Pictometry's PentaView System, affords a significant advantage with respect to overall image quality.



Ratio of Maximum Slant Range to Nadir Range Increases with Distance from Nadir

The dominant effect is exposure falloff and results from an increase in slant range or maximum path length from the surface being imaged to the sensor. When using a small format sensor, the difference in path length between the nadir point and the maximum slant range is minimal and increases by approximately 4.5% from nadir to corner of the frame. In a large format camera, if the corner is at 38 degrees from nadir, the path length increases by 26%; if the corner is at 55 degrees from nadir, the path length difference is over 74%.

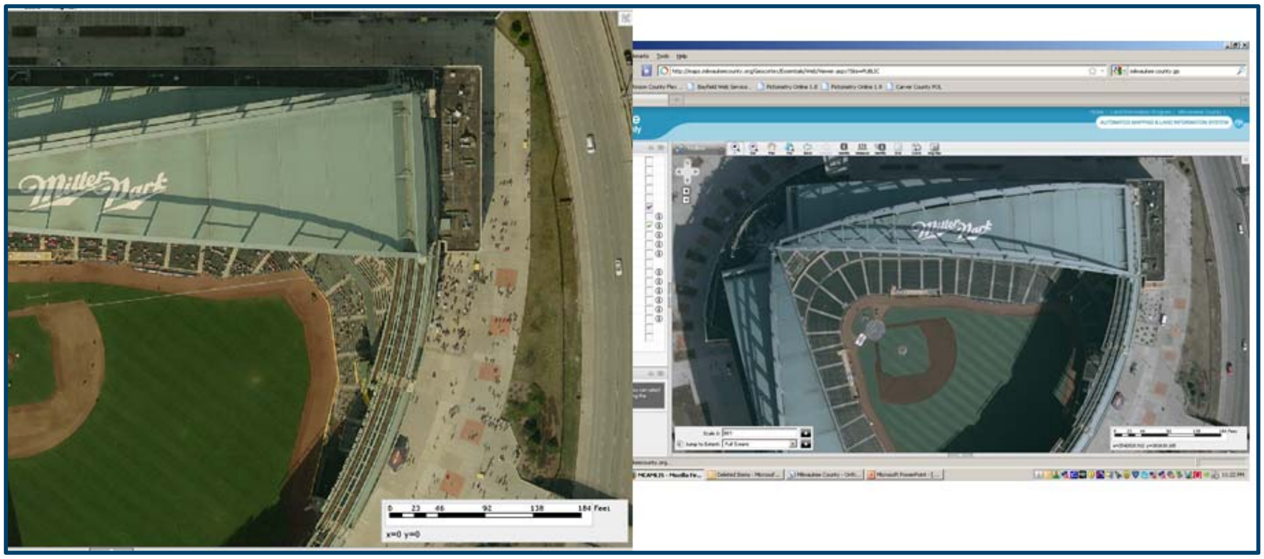
This increase can be seen in the diagram here. The primary effect is the buildup of blue light scattered by the increase in the amount of atmosphere that light is passing through on its way from the surface being imaged to the sensor.

Camera Calibration

Prior to image collection, and as part of the manufacture, the individual cameras are put through a rigorous calibration process developed by Pictometry and licensed to the USGS. The calibration is performed through the capture of a series of images from prescribed locations and at varied orientations of a stationary target cage. Targets are identified in the images collected via a semi-automatic process and a free-network bundle adjustment is performed to solve for camera interior orientation, including precise focal length, principal point location, and radial distortion coefficients. These parameters are then incorporated into the camera model used during subsequent image processing operations.

Each camera is also put through a color calibration process designed by Pictometry in order to generate a consistent response, ensuring consistent representation of ground features. The result of Pictometry color calibration can be seen throughout a project and is evident from a high level overview as well.

The below example shows the true to life representation of the roof of Miller Park achieved through Pictometry's PentaView sensor system as compared with the blue tinged result obtained from a traditional off-the-shelf mapping camera. This effect can also be seen in the grass on the baseball field itself.



Acquisition

Pictometry will coordinate with local and region air traffic authorities as required to ensure full legal compliance with FAA regulations and guidelines. Pictometry's fleet includes two different configurations of the PentaView Sensor System. The more prevalent configuration provides for an altitude of 5,500 feet for capture of 6-inch imagery through the use a 65mm nadir lens; alternatively, Pictometry operates 12 systems configured with a 120mm nadir lens, allowing for the capture of 6-inch GSD imagery from an altitude of 9,500 feet. Similar variability is available for other GSDs. This capability allows Pictometry to collect imagery at contracted GSD while working within FAA requirements.

System Alignment

In advance of capturing the data, an additional aerial bore sight calibration is performed on each of the systems involved in the project. An adjustment is then computed to solve for the alignment between the optical axis of each of the cameras and the internal coordinate axes of the Inertial Measurement Unit (IMU). This adjustment is then applied to the imagery captured throughout the project. Each system completes a bore sight flight at regular intervals to ensure that the sensors have stayed in alignment.

Data Capture

Once the cameras are calibrated and the system is aligned, data capture can begin. Throughout each of the capture missions, GPS/IMU data is logged on the aircraft, the GPS data is recorded at a minimum rate of 2Hz and the IMU data is logged at a minimum rate of 200Hz. Concurrently, multiple GPS reference stations are logging data on the ground. These reference stations may be either part of the NGS CORS network, or a base station set up and run by Pictometry or a licensed surveyor sub-consultant.

The imagery is nominally captured with a PDOP value of less than 8.0 and within 60 kilometers of an operating GPS reference station. Due to the small format of Pictometry's camera, and automatic aerial triangulation techniques available, Pictometry limits its sensor to 6 degrees of pitch and yaw; this limit can be utilized due to the narrow field of view of Pictometry's cameras which, by design, limits the off-nadir distance of features at the edge of the frame.

Imagery will be captured at 36-bit (12-bits per channel) and resampled to 24-bit RGB color for processing, with a planned forward lap of 60% and a side lap of 30%. Image collection will extend beyond the project area boundaries sufficiently far enough to produce orthoimagery fully covering the project area and a 400 foot buffer. Upon completion of collection, the data is transferred to Pictometry's processing facility in Rochester, NY.

Quality Control

During the capture process, Pictometry's Flight Management System performs real time checks of a variety of parameters, including but not limited to: rapid histogram analysis to detect exposure errors, camera orientation (i.e. roll, pitch, yaw) to ensure perspective, and camera position to ensure coverage.

Data Processing

GPS/INS Post-Processing

Upon receipt in Rochester, the data is immediately backed up and post-processing begins. Applanix POSPac software is utilized to post process the GPS/IMU data utilizing the SmartBase (IN-fusion). The SmartBase technology uses a centralized filter approach to combine the GPS receiver's raw observables (pseudorange and phase observables) with the IMU data (tightly coupled solution). The Applanix SmartBase engine processes the raw observables (phase and pseudorange to each tracked satellite) from a minimum of four to a maximum of 50 continuously-working GPS reference stations surrounding the trajectory. The computed ionospheric, tropospheric, satellite clock, and orbital errors at all the reference stations will be used to correct for the errors at the location of the remote receiver. The SmartBase Quality Check tool is utilized to perform a network adjustment on all the base-lines and reference stations in the network. Quality checks are also performed on the individual reference station observation files before the Applanix SmartBase is computed. The result of this process is that the integrity of the reference station's data and coordinates are known before the data is processed.

The smoothed best estimated trajectory (SBET) is computed from the GPS track (including Kalman Filtering). Once the final trajectory has been generated, it is applied to the imagery on the basis of the individual time stamps associated with each frame. The location (X, Y, Z) and orientation (Roll, Pitch, Yaw) values derived from the SBET and assigned to each frame serve as the initial exterior orientation (EO) values for the aerial triangulation phase of the processing.

Apply Trajectory Information

The next step in the production of Pictometry's Oblique Imagery data is the application of the post-processed trajectory data with the oblique imagery. Each image is assigned a new camera center and orientation (exterior orientation or EO) based on the post-processed trajectory. This EO serves as the origin point for all subsequent measurements and calculations on oblique images and as the input into the Aerial Triangulation step for AccuPlus orthogonal imagery.

Imagery Processing

In parallel with the trajectory post processing, the raw image data enters the post-processing phase. Pictometry's proprietary imager processing software suite, designed in conjunction with Pictometry's flight management system is used to convert from raw sensor pattern to finished RGB image and has been specifically designed to extract high detail with few image artifacts and aliasing patterns. Pictometry's custom cameras have been designed for high image clarity with very flat field, low-distortion, photogrammetric lenses and no anti-aliasing filters.

Quality Control

After the development process, the imagery is put through a rigorous QA/QC process whereby images of low quality, due to either improper exposure or sensor artifact, are identified and marked for recapture. Pictometry uses both proprietary automated software and human examination when considering whether to reject or accept an image for production. Pictometry's in house Image Processing Department checks for any defects while assessing the quality of the imagery.

Pictometry Imagery Capture/Initial Processing Checklist

Area Identifier (FlightGroup or CPID)

Task	Description	Production Complete	Supervisor Sign-off
1	Camera Calibration (interior orientation)		
2	Camera color calibration		
3	System alignement/boresight		
4	Flight plan		
5	Primary data acquisition		
6	GPS/INS post processing		
7	Coverage review		
8	Reflies scheduled		
9	Refly data acquisition		
10	Refly GPS/INS post processing		
11	Final coverage review		
12	Tie Point checks (obliques & orthos)		
13	Apply DEM data		
14	Apply image equlaization (color correction)		
15	Orthorectification of individual frames		
16	Final coverage Check		

Pictometry Quality Checklist for Acquisition and Initial Processing

Orthogonal Imagery Processing

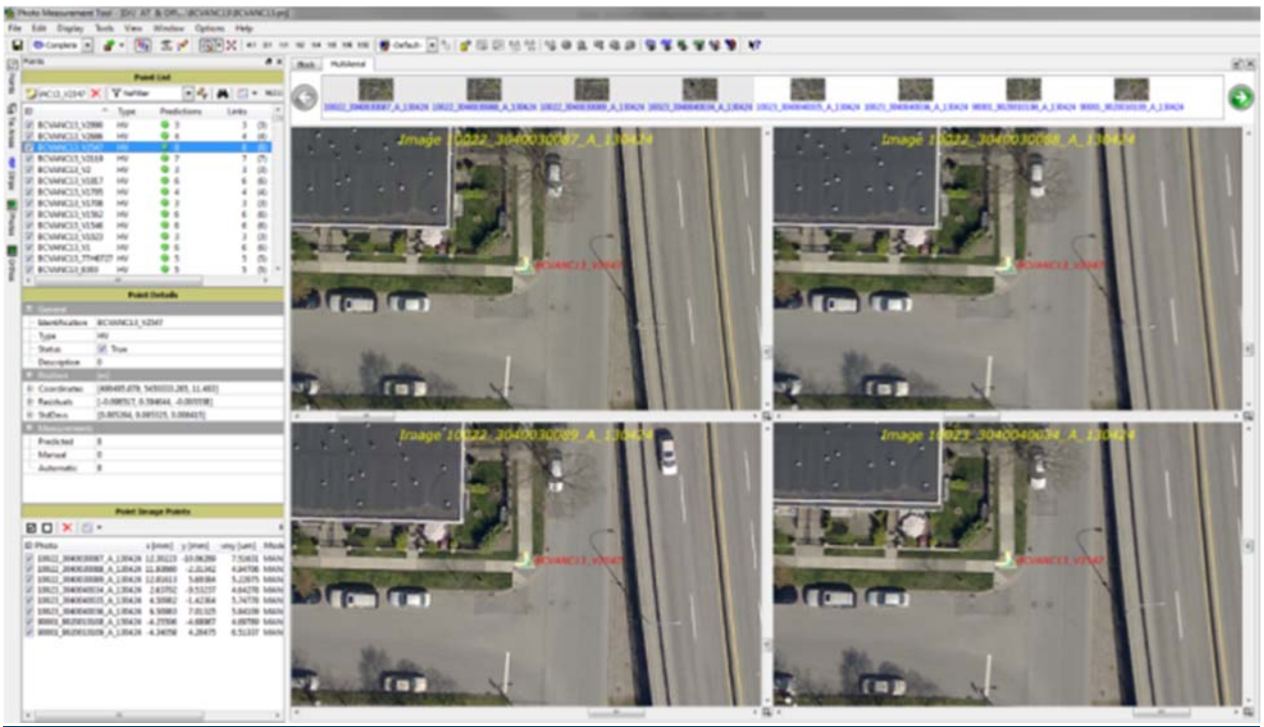
Aerial Triangulation

Pictometry's solution includes aerial triangulation of all source frames to be involved in the creation of the ortho mosaic. To expedite this task Pictometry has a developed a parallel workflow for the developing of its captured imagery. Concurrent with the de-mosaicking process (conversion of sensor data from RAW to RGB format or 'development') of the oblique imagery into JPEG for use in Pictometry's standard product, Pictometry will develop the nadir imagery directly to TIFF making the imagery immediately available to its Aerial Triangulation staff for review of captured image polygons enabling the verification of complete imagery coverage, the verification of available photo-identifiable GCPs for use in the AT solution and the ability to begin initial tie point generation (TPG). This updated approach saves critical time in the review process and limits potential delays in the production of the final Aerial Triangulated blocks for use in subsequent orthorectification and orthomosaic production tasks.

Pictometry will perform automatic aerial triangulation (AAT) to ensure proper alignment between individual frames and the overall accuracy of the resulting orthophotos. Pictometry uses Inpho's Match-AT software to perform the all phases of the AAT. As input to the overall AAT process, Pictometry utilizes the exterior orientation (EO) values resulting from the post-processing of the airborne GPS and INS data, the surveyed ground control points (GCPs), and the calibrated camera model parameters. The AAT process in general consists of two steps: the creation of image measurements, and the bundle adjustment of those measurements. The overall process will move between these two steps in a back-and-forth fashion until a final adjustment is made and deemed to meet the standards required. The final output of the AAT process is the final, adjusted set of exterior orientations, the triangulated EOs.

Image Selection

Pictometry's capture process, which also captures oblique imagery, frequently results in the collection of duplicative imagery. Pictometry photogrammetric staff members carefully evaluate these images to ensure that the best available frames are chosen for inclusion in the aerial triangulation and subsequently the ortho mosaic creation processes. This careful selection of imagery not only minimizes the amount of corrections in the final mosaic, but more importantly significantly reduces the associated time and costs of said corrections. Although the use of Pictometry's PentaView Sensor System results in a larger number of frames than a typical large format camera, there are numerous benefits associated with the utilization of a small format camera for orthogonal imagery capture. Just a few of these benefits are the collection of imagery with a more nadir perspective, better radiometric qualities due to a minimization of exposure falloff, and less absolute horizontal error being introduced by both the IMU and the digital elevation model used in the orthorectification process. These benefits are described in detail in the *Small Format Advantage* discussion above.



Inpho's Photo Measurement Tool

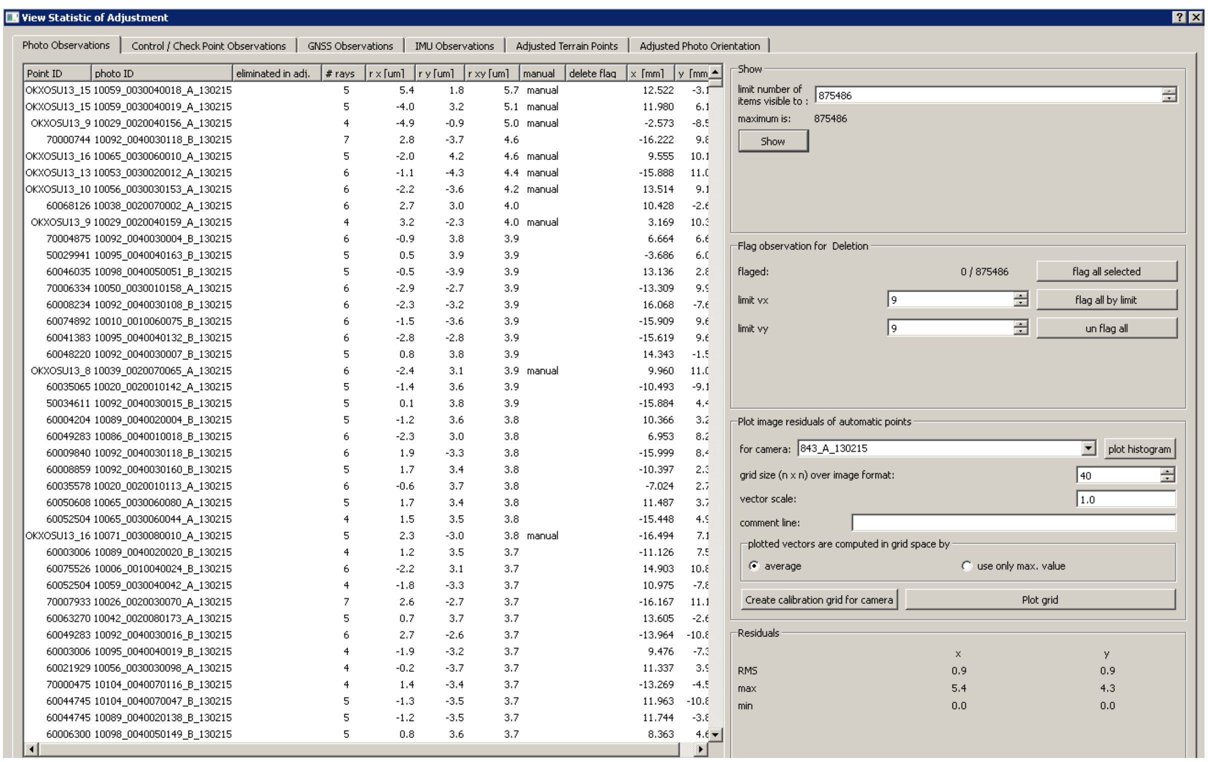
Image Point Measurement

The image measurement process consists of a series of steps. In the first step, each of the surveyed GCPs is measured in each available image containing the surveyed point. These measurements will later serve to constrain the adjustment. In the second step, the software will be used to generate automatic tie points between the frames. Upon completion of the initial automatic tie point generation, a manual review is performed to ensure proper distribution and density of tie points. The targeted total density is approximately 100 measurements per frame. Any images or areas found to be lacking in the desired number of points will be reviewed. If any low density areas, other than water bodies or extremely low texture areas, are identified, the images and areas will be put through an additional automatic point generation run and/or have points measured manually. As part of the manual review process, any residual points in water areas are manually removed. If the size of the project exceeds (approximately) 25,000 frames, Pictometry will treat the project as multiple blocks and undertake the additional step of measuring common points in the overlap regions of the individual blocks. The values of these points in each of the adjustments will be compared in order to ensure a seamless transition across the block boundaries in the final orthomosaic. This is a proven method of ensuring mosaic quality that has been successfully applied in projects with as many as 28 contiguous AT blocks. Pictometry estimates that if the entirety of SEWRPC's 2967 square miles were collected at full 3" resolution, approximately 10 blocks would be required.

Bundle Adjustment

The bundle adjustment process consists of a large least squares adjustment and is used iteratively, first to evaluate the status and consistency of image point measurements and ultimately the overall quality of the finalized exterior orientations and to ensure that the standards of the final deliverable will be met. The inputs to the bundle adjustment consist of the initial EO values, surveyed ground control coordinates, image measurements, and the calibrated camera model parameters.

After the preliminary bundle adjustments have been completed, Pictometry will perform an adjustment with all surveyed ground control points "set to check" (an unconstrained adjustment) to independently evaluate the relationship between the captured imagery data and the independently surveyed ground control coordinates. After each subsequent bundle adjustment, Pictometry will review all residuals between control points and tie points, and compare the calculated coordinates of any additional available check points to the surveyed coordinates. Pictometry will perform quality control checks and prepare a statistical analysis of the error propagation and the accuracy of the resulting imagery. Image point measurements will be evaluated and, as needed, new automatic or manual tie points may be added or removed to increase the strength of the solution.



Sample Adjustment Statistics

The bundle adjustment process will be deemed complete upon the review and verification, by Pictometry's professional staff, that the resulting statistical values, of the Aerial Triangulation process, meet those values outlined in the project specifications below.

Orthorectification and Mosaicking

Terrain Model

To perform the orthorectification, Pictometry will utilize the triangulated EOs, the calibrated camera model parameters, and an appropriate elevation model. The orthorectification process will be used to remove horizontal displacement caused by terrain height variation, earth curvature, and camera based distortions. The orthorectification process requires a resampling of the imagery; a cubic-convolution method is utilized to perform this resampling.

The elevation model to be used will be determined based on the required accuracy/GSD of the imagery. In areas where an elevation model of sufficient accuracy to support the required accuracy does not exist, Pictometry will either utilize Inpho's Match-T software to extract a surface to support orthorectification or possibly extend the area of a contracted LiDAR capture to include areas of insufficient elevation data.

Per the above discussion, *Pictometry AccuPlus Orthogonal Imagery – The Small Format Advantage,* Pictometry's sensor system relies to a significantly lower extent on the elevation model to establish accuracy in orthophotography than a traditional large format camera. This provides the ability to utilize a terrain model with a lower level of accuracy to support orthorectification of imagery with a high level of accuracy.

Quality Control

After ortho rectification, each frame containing a control point measurement is checked against the surveyed coordinates to ensure proper rectification.

Sample Result of Color Balancing

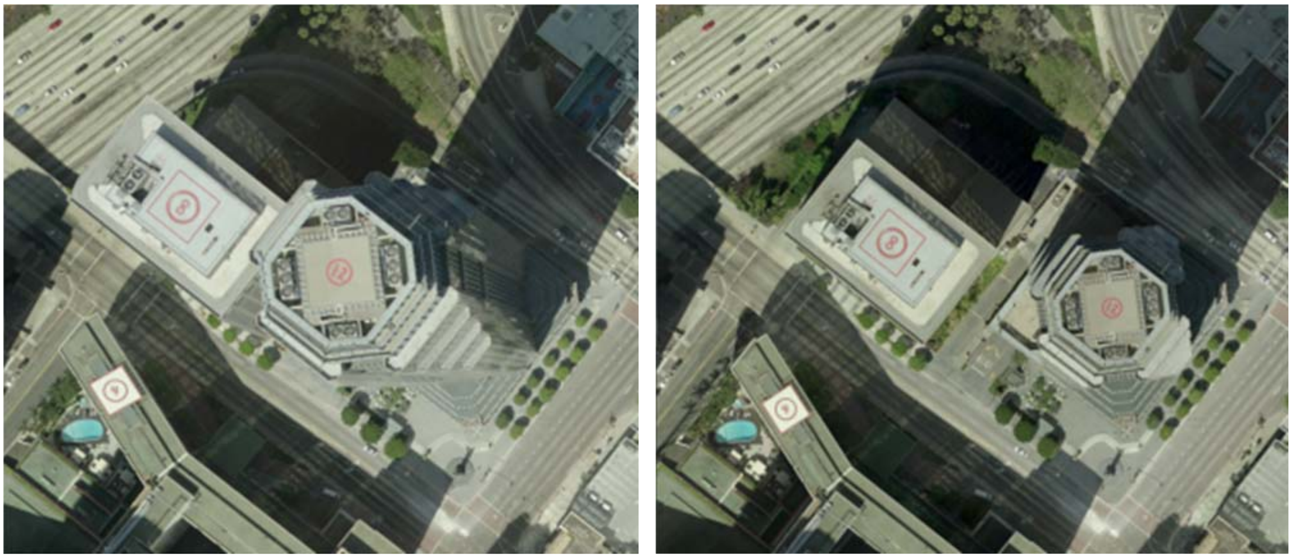
Color Balancing

Consistent radiometry/photometry is recognized as an important characteristic of an ortho mosaic. Pictometry has developed techniques at every step of the process in order to ensure this consistency in its final ortho mosaics. First, Pictometry's PentaView Sensor System is put through a color calibration prior to deployment in order to ensure a consistent response from each sensor in Pictometry's fleet. Next each exposure is carefully monitored and data pertaining to that exposure stored for use during subsequent processing. Prior to ortho rectification, Pictometry applies its proprietary brightness equalization and color balancing software techniques. Both low and high spatial frequency adjustments are applied. Though infrequently the case, following orthorectification, Pictometry has the option to utilize Inpho's Ortho Vista during the mosaicking process if any further correction is deemed desirable. During the review process, final local adjustments of brightness values, color, and contrast based on image content are performed as necessary.

Mosaicking

Following radiometric balancing, the OrthoVista software package will be utilized to generate automatic seam lines between source frames. By utilizing the existing and/or newly established building outlines, Pictometry will enhance the Inpho generated seam line locations to reduce all seam lines running through established structures saving significant time during the orthomosaic production process. Pictometry will then manually review and edit any remaining feature misalignments due to seam lines which pass through features located above the DEM.

In addition to editing for geometric considerations, Pictometry also edits seam line placement for aesthetic purposes, including elimination of split vehicles and shadows where possible. During the seam editing process, Pictometry technicians verify feature alignment between frames.



Before and After Building Correction

Building Correction

Features which are elevated with respect to the DEM are subject to scale increase and radial displacement (e.g. building lean). Due to the narrow field of view of Pictometry's small format camera, building lean is minimized in most cases. Any residual building tilt shall be eliminated so that all roads are visible. To the extent possible utilizing the frames available, Pictometry will manually correct buildings which obstruct transportation features due to either scale increase or building lean.

Bridge Correction

As with buildings and other elevated features, bridges are subject to the effects of scale increase and radial displacement. Pictometry will manually correct bridges as necessary in order to ensure proper planimetric placement and to eliminate distortion due to variances in the DEM below the bridge deck. Bridge correction is accomplished through the use of Pictometry's proprietary software to re-orthorectify bridge decks to the appropriate elevation; properly scaled bridge decks are placed into the ortho mosaic after using best available imagery to properly represent ground level features.

Before and After Bridge Correction

Water Bodies

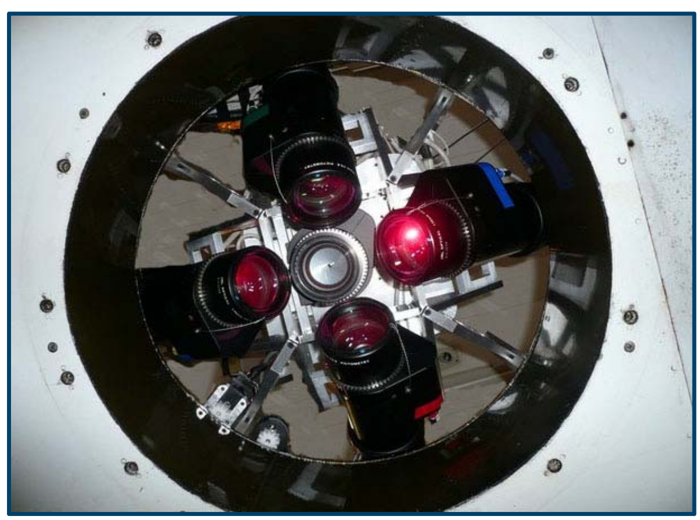
In order to preserve uniformity of appearance, Pictometry will utilize the seam editing process to attempt to source inland water bodies from a single frame where possible. In areas where this is not possible, Pictometry offers two options. The first is to manually smooth differences in the color of water bodies and/or apply a single color to said water bodies. The second is to maintain the actual appearance and preserve the visibility of sandbars and other water features.

Quality Control

Pictometry's quality procedures include a full manual review of all post correction tiles, during which mosaic seam lines are evaluated for proper placement, buildings are check for lean; bridge correction is verified and the overall mosaic reviewed a final time for overall consistency and compliance with project specifications.

Metadata

Project level metadata describing the orthoimagery production process shall be submitted as a deliverable. Unless otherwise specified by the client, one (1) Project Level Metadata file shall be delivered for each imagery type – e.g. GeoTIFF tile dataset or area-wide MrSID mosaic, with corresponding names. Optionally, file Level Metadata file can be made available.



Pictometry QA/QC Orthoproduction Checklist			
Area Identifier (FlightGroup, CPID or AT Block)			
Task	**Description**	**Name / Date Complete**	**Supervisor / Sign-off (date)**
1	Verifiy coverage area		
2	Ground Control (GCP) Review		
3	DEM Review		
4	DEM update		
5	Initial Equlaization		
6	Polygon/Coverage Analysis		
7	Generate Overviews		
8	Project Setup		
9	Measure GCPs		
10	Tie Point Generation (TPG)		
11	Initial Post Process		
12	Manual TPG and Terrain Points		
13	Unconstrained Post Process		
14	Final Post Process		
15	Aerial Triangulation Complete		
16	Orthorectification of individual frames		
17	Review GCPs in Orthorectified frames		
18	Verification of Tiling Scheme/Datum		
19	Mosaic tile generation		
20	Seamline review & create fix location shapefile		
21	Seamline edits		
22	Color balance review & create fix location shapefile		
23	Artifact review & create location shapefile		
24	Buidling/Bridge review & create fix location shapefile		
25	1st gen. Ortho corrections		
26	Initial tile review		
27	2nd gen. Ortho corrections		
28	Final tile review		
29	Final coverage Check		
30	Metadata Prep/review		
31	Delivery Prep/review		

Pictometry Ortho Production Quality Control Checklist

	Product Ground Sample Distance			
Parameter	**3”**	**4”**	**6”**	**9”/12”**
Acquisition				
Altitude (Primary)	*2500 ft.*	*3500 ft.*	*5500 ft.*	*8500 ft.*
Focal Length (Primary)	*65 mm (nadir)*			
Altitude (Alternate)	*5000 ft.*	*6000 ft.*	*9500 ft.*	*N/A*
Focal Length (Alt.)	*120 mm (nadir)*			
Camera System	*Pictometry PentaView Imaging System*			
Bit rate	*12 bits per channel – resampled to 8 bits during processing*			
Overlap – Forward/Side	60%/30%			
Solar Angle (Typical)	*30 degrees or greater and/or most optimal four-hour window*			
Snow Cover	*Ground free of snow cover*			
Clouds	*Imagery free of clouds*			
Vegetation	*Deciduous vegetation less than 30% full bloom*			
Nominal Frame Count				
Orthogonal per mile^2	*81*	*42*	*31*	*12*
Aerial Triangulation				
Automatic Point Measurements	*$RMSE_x$ and $RMSE_y$ < 1 pixel size*			
RMSE of manual measurements	*$RMSE_x$ and $RMSE_y$ < 15 micron in x and y*			
RMSE of survey control points	*< 0.38 ft.*	*< 0.50 ft.*	*< 0.75 ft.*	*< 1.13 ft.*
Ortho Imagery				
Pixel Size	*0.25ft./0.075m*	*0.32ft./0.10m*	*0.5ft./0.15m*	*0.80ft./0.24m*
Mosaic	*Automatic seaming with manual edits*			
Buildings	*Sourced from one image where possible*			
Building/Feature Lean	*Corrected to avoid obstruction of transportation features*			
Bridge Decks/Elevated Roadways	*Orthorectified to correct elevation for horizontally correct feature representation*			
Accuracy*				
$RMSE_x$ or $RMSE_y$	*0.77 ft.*	*1.15 ft.*	*1.55 ft.*	*1.95 ft.*
$RMSE_r$	*1.09 ft.*	*1.63 ft.*	*2.19 ft.*	*2.76 ft.*
NSSDA (95%)	*1.88 ft.*	*2.8 ft.*	*3.8 ft.*	*4.8 ft.*
NMAS Scale	*1”=50’ 1:600*	*1”=75’ 1:900*	*1”=100’ 1:1200*	*1”=125’ 1:1500*
* *Accuracy to increased specification may be available*				

Preparation of Deliverables

Upon completion of the area wide mosaic Pictometry will tile the imagery to the schema specified by SEWRPC in the RFP. Any and all 12-inch and 6-inch pixel resolution orthophotography will be tiled into 10,000 x 10,000 foot tiles based on the Wisconsin SPCS. Any 3-inch pixel resolution orthophotography will be tiled into 5,000 x 5,000 foot tiles based on the Wisconsin SPCS. Orthorectified GeoTIFF files represent "tiles" cut at even intervals (e.g. 2500 feet X 2500 feet) and cut at even foot grid lines with no overedge. Tiles are accompanied by an index sheet and shape file suitable for loading into ArcGIS. The index sheet shall include tile boundary and filename. Tiles split by the project boundary are completed to their full extent.

File Naming Convention

As specified in the RFP, Pictometry will adhere to the naming convention spelled out by SEWRPC. Specifically:

> *The 12-inch and 6-inch resolution digital orthophoto files shall follow the file naming convention of "im15_10K-12_eeee_nnn.tif" where the prefix "im15" indicates a 2015 image file; the notation "10K-12" indicates a 10,000 by 10,000 foot color 12-inch pixel resolution orthophoto; the notation "eeee_nnn" indicates the easting coordinate ("eeee"), in thousands of feet, and the northing coordinate ("nnn"), in thousands of feet, of the southwest corner of the image; and ".tif" is the extension for the GeoTIFF file format. For example, a file name of "im15_10K-12_2505_275.tif" indicates a 2015 orthophoto file in GeoTIFF format with 12-inch pixel resolution covering a 10,000 by 10,000 foot tile originating at an easting of 2,505,000 feet and a northing of 275,000 feet on the Wisconsin SPCS grid.*
>
> *Similarly, the 3-inch resolution digital orthophoto files shall follow the file naming convention of "im15_5K-3_eeee_nnn.tif" where the prefix "im15" indicates a 2015 image file; the notation "5K-3" indicates a 5,000 by 5,000 foot color 3-inch pixel resolution orthophoto; the notation "eeee_nnn" indicates the easting coordinate ("eeee"), in thousands of feet, and the northing coordinate ("nnn"), in thousands of feet, of the southwest corner of the image; and ".tif" is the extension for the GeoTIFF file format.*
>
> *The "world" file accompanying each GeoTIFF file shall be named similar to the GeoTIFF file but contain the ".tfw" file extension.*

Orthophotography Deliverables

- Project Report
  - Aerial triangulation results/summary
  - Description of methods and deliverables
- Orthogonal Imagery
  - GeoTIFF format tiles; tiled and named according to requirements in RFP and above
  - ECW or MrSID wide-area mosaic; one per county at preferred compression level
  - Data delivered in NAD27, Wisconsin State Plane South Zone, US Survey Feet
  - Other specifications as indicated in the chart above
- Aerial Triangulation Data
  - Triangulated nadir frames with supporting information to include exterior orientation and camera model parameters (optional)
- Metadata
  - FGDC compliant metadata

Digital Oblique Photography

Oblique Imagery Acquisition

The acquisition of Pictometry's oblique imagery is performed in conjunction with that of its ortho imagery and is fully described above in the section on acquisition of orthogonal imagery.

Oblique Image Processing

Initial Processing Steps

The initial processing steps for Pictometry's Oblique Imagery happens in conjunction with the initial processing of orthogonal imagery. These steps, including image development (de-mosaicking), image quality review, and trajectory post-processing (GNSS/IMU processing) are described in detail in the data processing section preceding that on orthogonal image processing.

Apply DEM Data

In order to ensure accurate measurements on single frame images, (i.e. rather than using stereo pairs) it is necessary to incorporate surface data into the imagery. Pictometry applies DEM data to its oblique frame images and does so using a proprietary patented technique known as a Tessellated Ground Plane (TGP). This process is the oblique analog to orthorectification. Whereas in orthogonal frames, the raw image data is warped and rewritten as a regular rectangular grid in the orthorectification process, for oblique frames, the original image is left unperturbed in order to preserve the natural perspective; the data behind the image is 'warped' to match the image.

The TGP can be thought of as a grid of elevation values, each creating a triangular facet similar to a triangular irregular network (TIN), yet not irregular. The TGP is appended to the image in a trailer; the density of the TGP can be modified to suit customer needs. A very dense grid will provide the highest degree of accuracy, while a less dense grid will provide for smaller files. Pictometry will work with the SWRPC and its member counties to reach an agreed-upon specification.

Image Library Preparation

Upon completion of the TGP process, the data is built into a library structure that supports rapid image search for delivery to the client. The Image library is both copied to delivery media and uploaded to Pictometry's Hosted Solution Servers for deployment through Pictometry Connect.

Imagery Deployment Options

Pictometry offers both a solution for workstation or desktop use, Electronic Field Study (EFS) and a web-based application, Pictometry Connect. Included with the web-based application is the ability through the Integrated Pictometry Application to push deployment to public facing web sites. Arriving shortly to the web based solution is the ability to set the AccuPlus Ortho Mosaic as the default orthogonal image, providing full existing functionality with the mosaic that previously only worked with frame images. This functionality will be available Q3 2014.

Desktop Solution – Electronic Field Study (EFS)

Pictometry provides its Electronic Field Study (EFS) software with its image library. EFS provides the user with access to Pictometry's patented toolset for making measurements directly on a single oblique image. Among the tools included are measurements of distance, area, height, bearing, angle of turn, pitch, and elevation. Navigation tools allow the user to pan, zoom, and rotate viewing angle. Imagery can be exported and or printed directly from EFS.

Electronic Field Study provides features that meet the needs of a diverse group of users, including:

Search for images in various ways

- Click a point on a map or image and view images that contain that point.
- Enter a location's geographic coordinates and view images that contain the coordinates you entered.
- If you have GIS data covering the same geographic area as the images in your Image Warehouse, you can enter a street address and find all images that show that address; and you can find images based on other text fields within the GIS data.

View related image

- View an image that is geographically adjacent to the one you are viewing
- View the same area from a different "shot level" (altitude).
- View the same area from a different compass direction.
- View an area from five compass directions (N, S, E, W, and orthogonally) at the same time.
- Locate points of interest by moving along a path, within and between images. As you near an image's edge, EFS searches for (and seamlessly swaps in) the best available adjacent image.

Measure and annotate images

- Measure the height, width, or length of items within an image in a unit of measure you specify.
- Measure the area of any part of an image in a unit of measure you specify.
- Accurately measure areas, heights, or lengths of items in images—whether the items are on or above the ground.
- Click on any item in an image and view its coordinates.
- Click on any item in an image and view its elevation, or calculate differential elevation.
- Find out the bearing—the orientation from True North—of an object, such as a road. Find out the angle of two intersecting lines.
- Annotate an image with text, lines, circles, icons, points, or links to files (such as documents or spreadsheets). Annotate an image with measurements taken by using EFS measurement tools. The annotation can pertain to a single image or to all images that contain the same geographic coordinates.

Overlay and query GIS data

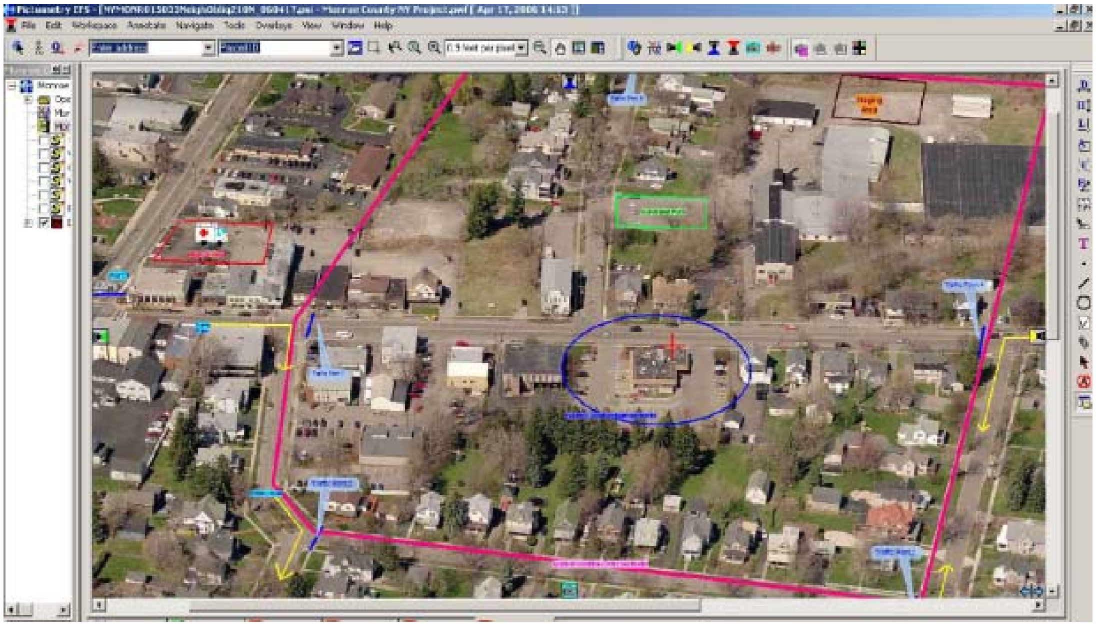
- Overlay images with GIS data (contained in shape files and SDE databases).
- Overlay images with labeled GIS data. Choose a GIS text field that EFS will automatically display with each unit of GIS data.
- Query a location to view its GIS data.
- Search for GIS text data in shape files and SDE feature classes, and view the images associated with that data.

Overlay grids

- Overlay an image with a user created circular or rectangular grid by using a tool on an EFS toolbar.
- Enter and store data in grid segments.
- Import the format of a shape file or an SDE database to use as a template for entry of data into grid segments.
- Export a grid and its data to a shape file or to an SDE database.

Overlay and view image polygons, sector maps, and contour

- Overlay images with image polygons that show the "footprints" of the other images.
- Overlay maps with sector maps, dividing the area into square-mile subdivisions.
- Overlay images with elevation contour lines.



Standard EFS GUI

Export and import files and overlays

- Section off portions of images, crop as necessary, and export the results in various image file formats.
- Export images, image polygons, and measurements to files that can be imported into other applications or used by other EFS users.
- Import elevation files (if your images don't contain elevation data) so you can factor in elevation when analyzing a landscape.
- Import and export sector maps to share with other EFS users.

Organize a subset of images and related information

- Save a related collection of images (called a workspace) with related annotations and files for later use.

Change Analysis Software (Desk-top Solution)

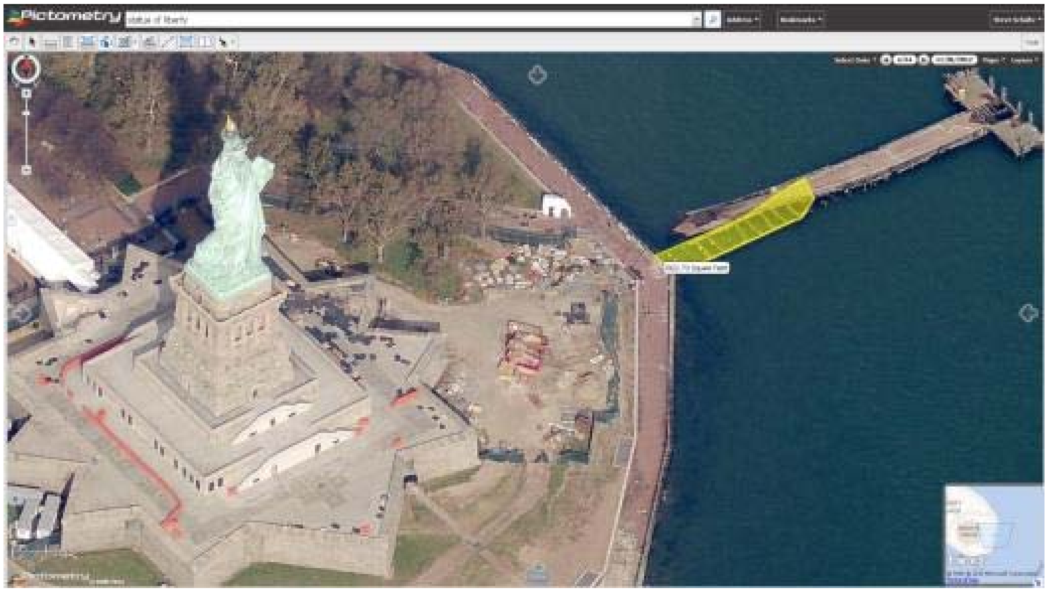
As part of its Desktop Deployment offering, Pictometry offers its Change Analysis Software Package. A desktop solution, Pictometry's Change Analysis software enables users to visually view the change candidates resulting from the change detection process (overlain side-by-side) on new and old imagery without closing windows or executing additional applications. The Change Analysis workflow enables the user to quickly step from one change candidate to the next, affirming or denying each change candidate and storing the results in the attribute table for later review. If Pictometry imagery and software tools are used, users can verify and analyze the changes using up to 20 different high-resolution oblique and orthogonal images, and can measure distance, height, elevation, and area directly from the images. The combined ability to use Obliques and Ortho imagery simultaneously in this application allows for better analysis of the deliverables if shadows or occlusions exist.

Hosted Solution – Pictometry Connect

Pictometry Connect is a secure, web-based solution that combines high resolution aerial imagery with customer GIS data to create a powerful system that is easily accessible and interactive. Users can upload, view, and analyze their location-based data against the backdrop of the highest quality aerial imagery in the world. Pictometry Connect is built on top of the Pictometry Analytics platform to provide the user with major benefits, including:

- Turnkey integration with leading GIS and CAD applications
- Access to Pictometry measurement and analytics tools
- Access to Pictometry image archive, featuring over 10 years of imagery
- Flexible deployment options including zero footprint installation
- Access to parcel boundaries information
- Reliable backup to onsite imagery and GIS data layers
- Full functionality for ortho mosaic as default ortho view (NEW!) (set for release Q3 2014)

Pictometry Connect has extensive support for GIS data and overlays including nationwide parcel and street data and an easy way for users to upload information from Esri ArcMap® 10, including maps, GIS data, symbology/icons and thematics. The base code is modular, allowing it to be used in a variety of implementations, including Flex, Silverlight, ActiveX, and in mobile applications. Pictometry Connect applets have been written for ArcGIS Server, ArcGIS Desktop, AutoCAD Map 3D, AutoCAD Civil 3D, and numerous computer aided dispatch and E911 call-taker applications.



The Pictometry Connect browser application showing an area measurement on post-Sandy imagery of the Statue of Liberty

Pictometry's hosted solution (Connect) offers the following deployment options for the County. Moreover, with everything hosted by Pictometry, the County may then deploy through (but not limited to) the options noted below:

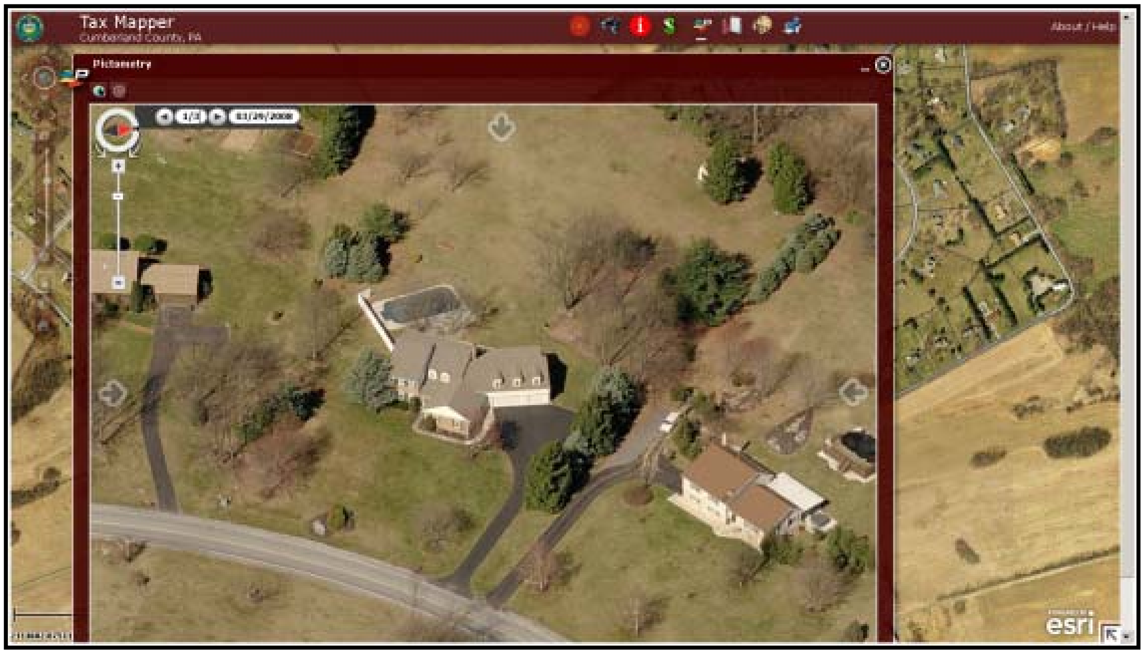
- Desktop – Esri or Autodesk® turnkey integrations
- Server – Pictometry for ArcGIS Server (Flex and Silverlight) and Pictometry Image Navigator™
- Web-based via Pictometry Online
- Select 3rd Party Software Packages
- Directly embedded into customer software - Integrated Pictometry Application (IPA)

Pictometry Framework

All Pictometry Connect products feature the same technology core, the Pictometry Framework. The platform is built on a proprietary code base that provides a modular toolset of reusable/sharable components. This allows for a consistent look and feel which offers a seamless user experience among applications and will serve as the basis for new technologies.

Available GIS Options

Connect provides access to Pictometry imagery and customer data in a high availability environment. In the Connect environment customers can manage and configure their own data (GIS, maps, imagery); whether that data is hosted by Pictometry or is maintained on the customer's own servers. Pictometry provides several pathways for customers to import their GIS layers to its Hosted Layer Service and then configure those layers to make them available for use with Connect.



Pictometry Connect as viewed within Esri

Pictometry Connect Uploader for ArcMap®

The most powerful data upload option is the Pictometry Connect Uploader for ArcMap® which is an add-on application that allows customers to upload their GIS layers and symbology from ArcMap® directly to their Connect account. This allows customers to take advantage of layers already configured in ArcMap®. Once uploaded the layers are ready to use with no further configuration needed. The Uploader supports the upload of point, line, or polygon layers. The source data can reside in Esri shape files, SDE, or as feature classes in file geo databases. The Uploader can render the features ("single symbol"), categories ("unique values" only), and quantities ("Graduated colors" only) properties of ArcMap® layers.

When layer is uploaded, that layer's visibility settings (the minimum and maximum zoom levels at which the layer is displayed or not displayed in ArcMap®) are uploaded with the layer. In Connect, that layer will be displayed at the same zoom levels as it is in ArcMap®, without the need for establishing the layer's visibility in Connect.

GIS Uploader

Another option provided to facilitate the import of data to Pictometry's Hosted Layer Service, is Pictometry's GIS Uploader, a utility that allows the customer to copy data from their client machine into the Connect environment. The GIS Uploader is provided in two configurations: a web-based tool and a desktop application. Pictometry typically recommends the use of the online tool that does not require local installation. To utilize the web-based tool, the customer need only login to the admin site and navigate to the Manager GIS layers panel and choose the Upload Layers button. This activates the upload dialog which allows the user to browse their file system to the data to be uploaded. Pictometry Connect currently supports upload of data via the GIS Uploader in either Esri Shape File or KML format. Once the file has been selected it is uploaded onto Pictometry's staging server for processing (re-projection) and validations. If any errors are encountered they are presented to the customer before proceeding. Upon completion of data validation, data is published to Connect production servers and stored in a private, secure, redundant database and the layers made available for configuration.

The configuration process is initiated by navigating to the GIS configuration panel of the admin site. This panel allows the user to define visual and display properties, and utilize full text search queries and geocoders. Upon completion of the layer configuration process, Pictometry Connect provides the capability to perform subsequent uploads to the configured layer without running through the configuration process again, provided that the schema remains the same.

Pictometry Connect also includes a desktop version of the GIS Uploader. While the desktop version necessarily requires local software installation, it provides the customer with the capability to script uploads and automate the process by scheduling monthly, weekly, or even daily updates. The same process is followed once the data gets to the Pictometry staging servers.

Customer Hosted Option

Pictometry Connect can be configured to display data hosted on the customer's own servers or machines. This option may be useful if data is deemed sensitive or otherwise restricted from upload to external destinations. In such cases, Connect can be configured to interface with the customer's hosted secure Web Feature Service (WFS). WFS is an interface standard for serving feature data over the internet. This option requires ArcGIS server, MapServer, Geoserver (anything that supports WFS 1.1) with the service enabled. Using the URL, Connect can access their GIS data directly from their servers. The advantage to the customer is that data is immediately available in Connect once updated on their own site. Regardless of where the data resides (Pictometry or customer site or a combination of the two) the customer is given the ability to manage their GIS data (add layers, update layers, remove layers, reconfigure existing layers).

Additional Map and Imagery Options

Connect allows additional map and imagery options. The customer can host their own maps or ortho imagery by using Web Map Service (WMS). WMS is an interface standard for serving raster data over the internet. This requires ArcGIS server, MapServer, Geoserver (anything that supports WMS 1.0) on the customer site be enabled, provide us with a URL and Connect can access their maps and imagery directly from their servers.

Another option with ArcGIS server is to point Connect directly to the customer's ArcGIS REST API (Representational State Transfer - Web interface to services hosted by ArcGIS Server). Connect can then consume either dynamic or tiled imagery. For ArcGIS server customers this is the preferred method because this is enabled out of the box and does not have the additional overhead of WMS.

Pictometry can also host the customer's AccuPlus ortho imagery or non-Pictometry ortho mosaic imagery; the ortho imagery is then served up as another base layer.

Advanced Administrative Capabilities

Connect provides powerful rights management for administrators to provide data access to the proper users. The Administration Application allows the user to create sub-organizations within a parent organization. Each sub-organization can be governed by specific properties pertaining to that sub-organization alone and supports establishment of its own Administrator. By default, a sub-organization will inherit most of its properties from its parent. For example, layers configured for a parent organization, are automatically available to all of that parent organization's sub-organizations.

The Connect Administration application provides the administrator with the ability to monitor an organization’s usage over a specific timeframe and view reports that show this information. Data available for report generation includes user specific statistics. For parent organizations, the report includes usage data for that parent's sub-organizations also.

The new Connect Administration interface features an improved user experience for the management of sub-organizations. Specifically, the administrator can easily change between sub-organizations without leaving the current management page. A list of all sub-organizations is always visible providing that easy navigation. Additionally, searching for particular users or sub-organizations is simpler, with a unified search box. Completely new functionality includes the ability to divide up the organization’s concurrent users (seats) as desired amongst the sub-organizations.

Layers sharing is now handled using the new “Publish/Subscribe” model. A parent organization may publish its layers to any of its sub-organizations. A sub-organization can then decide whether or not they want to use this layer by subscribing to it or unsubscribing from it. A parent organization may choose to automatically subscribe to their selected sub-organizations, so they see these layers immediately.

Deployment Options – Integrated Pictometry Application

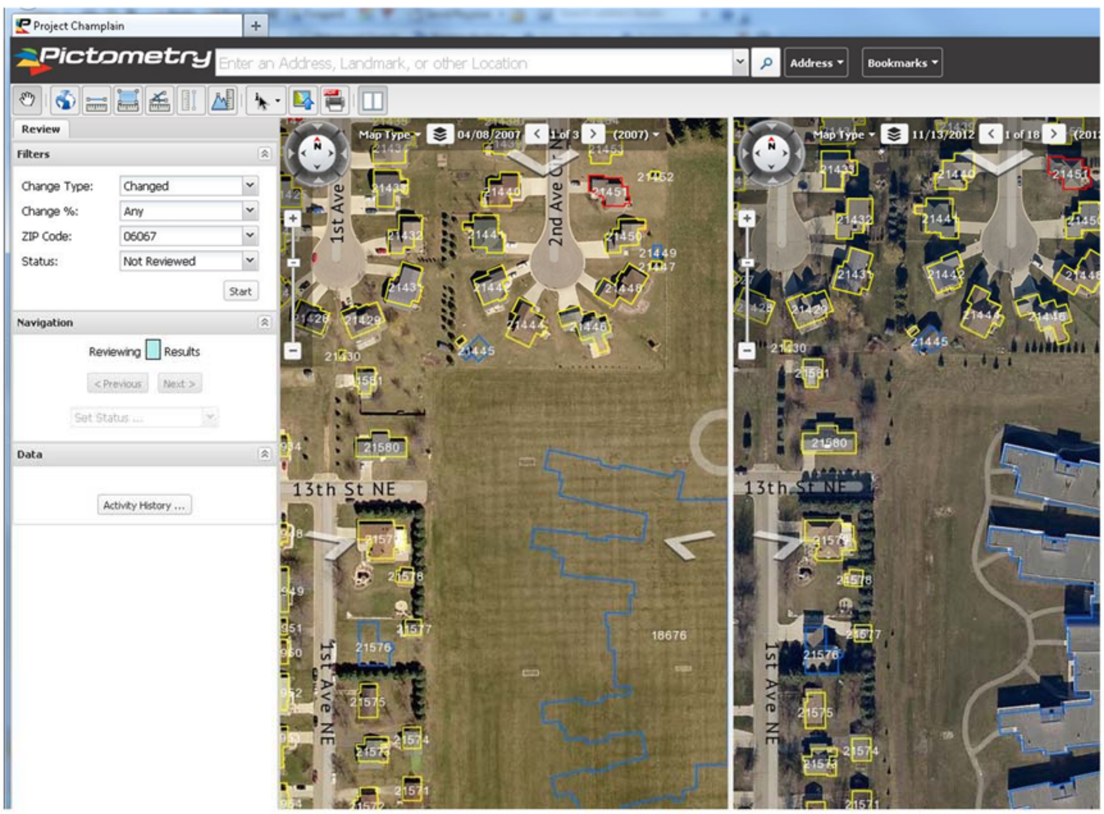
Pictometry Connect allows the user to easily and affordably deploy intelligent imagery, data, and tools enterprise-wide without the expense and burden of installing software or managing massive amounts of data. The Integrated Pictometry Application (IPA) is a web component that can be integrated with the client’s web application by using JavaScript and iframes. The IPA is loaded as part of the client’s web page and makes calls to Pictometry via the IPA JavaScript Library.

Once the web application has been set up to load the IPA on client computers, the IPA will communicate with the Pictometry API directly enabling access for users to Pictometry imagery and tools directly in the client’s web application.

A unique API key pair is generated for each customer environment. This key pair is used by the customer to generate a web page with a signed URL that authenticates and loads the IPA JavaScript Library from Pictometry when the page is loaded. Once the IPA JavaScript Library is fully loaded, the page Javascript can communicate with the IPA. For example, a new location can be set using a lat/long which will automatically move to that location. Available functionality depends on what specific IPA product is utilized. Pictometry offers a public facing Visualization IPA that only supports viewing of imaging and an Analytics IPA that includes all of the available measurement tools. One key advantage of the IPA is that the process of integration is greatly simplified, as the desired functionality has already been implemented.

Connect Assessment

As part of its Hosted Solution offering, Pictometry offers its cloud based Change Analysis Software Package, Connect Assessment. A web based solution, Pictometry’s Connect Assessment software enables users to visually view the change candidates resulting from the change detection process (overlain side-by-side) on new and old imagery without closing windows or executing additional applications. The end user has the ability to set the parameters for reviewing the deliverables prior to commencing any analysis. The searchable fields include Change Type (New, Changed, Demolished, etc.), Percentage of Change, by Jurisdiction and status of review (reviewed, reviewed accepted, on-site visit required, etc.) The Connect Assessment workflow enables the user to quickly step from one change candidate to the next based on some or all of the criteria populated in the searchable fields. As the end-user affirms or denies each change candidate and storing the results in the attribute table for later review, an admin dashboard allows for a review of the project status by individual working on the analysis, jurisdiction and percentage complete. If Pictometry imagery and software tools are used, users can verify and analyze the changes using up to 20 different high-resolution oblique and orthogonal images, and can measure distance, height, elevation, and area directly from the images. If the customer already has multiple years of imagery accessible by a regular Connect account those years will be available and allow a more thorough historical review. The combined ability to use Obliques and Ortho imagery simultaneously in this application allows for better analysis of the deliverables if shadows or occlusions exist.



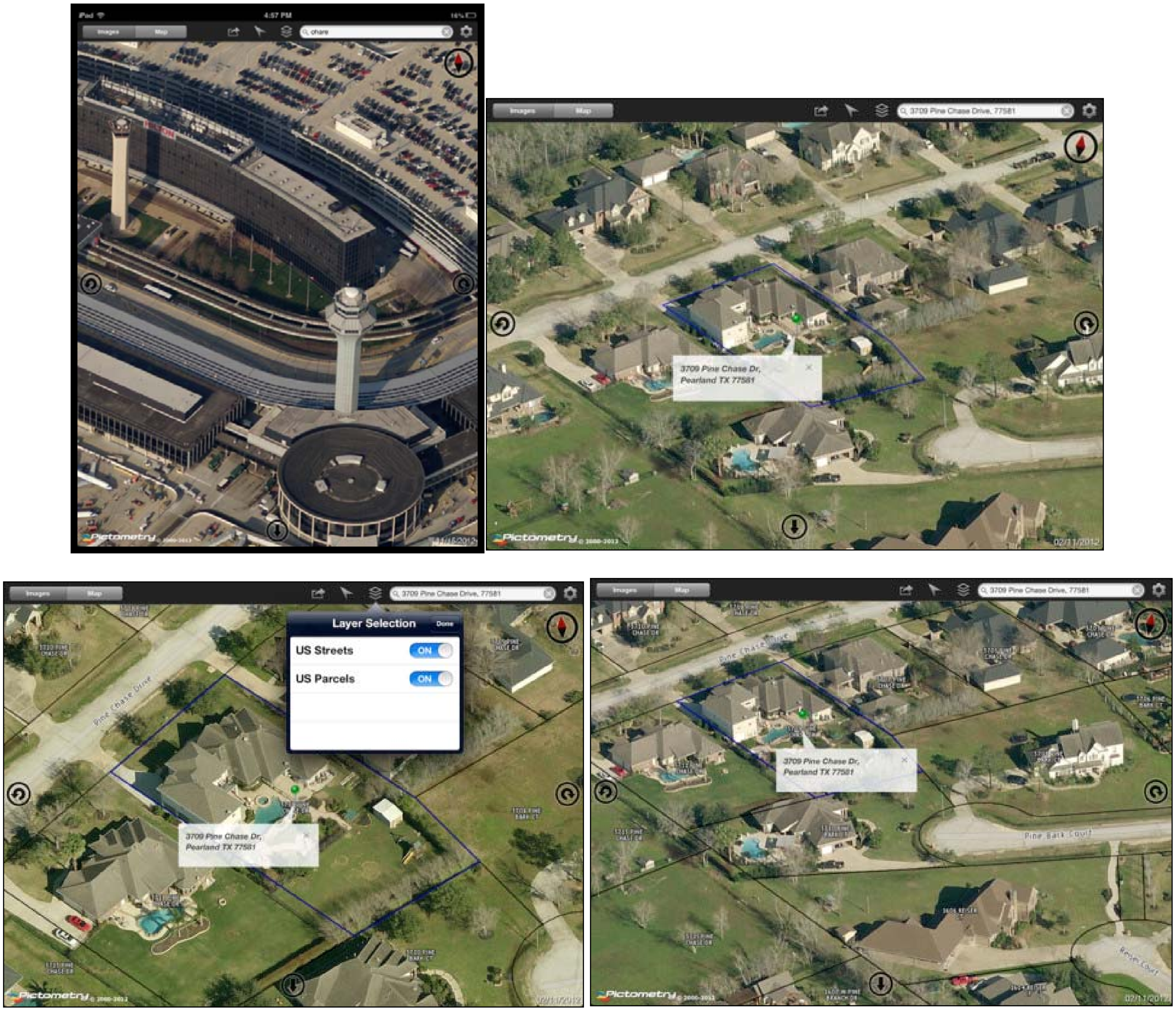
Connect Assessment

Pictometry Connect iPad Application

Pictometry customers are now able to access Pictometry vast image library from their iPads with Pictometry Connect Mobile. Available to Pictometry Connect and POL customers, Pictometry Connect Mobile provides visualization capabilities of high resolution imagery with a simple interface to navigate, pan and zoom. Users have multiple search options including by address, latitude and longitude coordinates, and specific points of interest. Upon downloading the free iPad app and entering their Pictometry Connect/POL credentials, users are able to search, overlay their GIS U.S. parcels and streets onto the imagery, tap to identify parcel data, export and email images, and be presented with imagery of their current location.

Within the application, users can pivot on the oblique images, displaying all five captured angles of a structure. Depending upon their Pictometry Connect account, users may have access to over 230 million aerial images covering more than 85 percent of the United States population, and will be able to zoom out from one parcel to assess an entire area or neighborhood. A pin can be dropped on any parcel, and a bubble will appear to reveal its address.

Pictometry Connect Mobile is available on the Apple iTunes App Store. Customers using devices other than an iPad, such as an iPhone or Android phone or tablet, can access a web-based version of the application via: https://pol.pictometry.com.



Numerous screen shots above show the capabilities of the Pictometry iPad application

Oblique Imagery Deliverables

- Four-way oblique image library covering designated project area at contracted GSD
  - Specifications as indicated below
- EFS and Connect Deployment Vehicles
  - Integrated Pictometry Application included

Parameter	Oblique Imagery Specifications			
	Neighborhood			Community
	3"/7.5cm	4"/10cm	6"/15cm	9"/22.5cm
Acquisition				
Flight Altitude (Typ.)	2500 ft.	3500 ft.	5500 ft.	8500 ft.
Camera System	*Pictometry PentaView Imaging System*			
Snow Cover	*Ground free of snow cover*			
POS	*Applanix POS-AV*			
POS Accuracy	*15cm RMSE*			
	0.015 degrees (roll/pitch)			
	0.035 degrees (heading)			
Clouds	*Imagery free of clouds*			
Vegetation	*Deciduous vegetation less than 30% full bloom*			
GSD				
Front Line	0.23ft. / 0.07m	0.30f.t / 0.09m	0.39ft. / 0.12m	0.74ft. / 0.23m
Middle Line	0.27ft. / 0.08m	0.35ft. / 0.11m	0.45ft. / 0.14m	0.86ft. / 0.26m
Back Line	0.33ft. / 0.10m	0.43ft. / 0.13m	0.55ft. / 0.17m	1.04ft. / 0.32m
Image Footprint				
Front Line	1,550ft. / 470m	2,000ft. / 610m	2,575ft / 785m	4,860ft. / 1,480m
Back Line	2,175ft. / 660m	2,820ft. / 860m	3,620ft. / 1,100m	6,840ft. / 2,085m
Front to Back	1,900ft. / 580m	2,475ft. / 750m	3,180ft. / 970m	6,000ft. / 1,830m
Image Counts				
Oblique per direction	40	22	16	6
Oblique per mile^2	160	88	64	24
Orthogonal per mile^2	81	42	31	12
Image Accuracy				
Pixel Placement Accuracy	*Nominal 1-3meters, elevation source dependent*			
Measurement Accuracy	*See Appendix B: Relative Measurement Accuracies for details.*			
All values are approximate and will vary with collection conditions.				

LiDAR Data

Pictometry offers LiDAR datasets collected at several different point density and accuracy levels to suit a variety of mapping requirements. The following details Pictometry's data collection and processing methodology and techniques, all of which have been chosen so as to be fully compliant with FEMA and USGS standards. Additional deliverables to support verification of compliance, including detailed reporting and ground truth surveys may be required to achieve full compliance.

Data Capture

LiDAR data is collected while atmospheric conditions are such that the air between the aircraft and the ground is cloud and fog free and the ground is generally snow free. Pictometry captures LiDAR using an Optech ALTM Gemini LiDAR sensor or equivalent. Pictometry's LiDAR system is capable of recording surface elevation measurements at up to 167 kHz, and at vertical accuracies up to 5cm. For reference three typical operational configurations are shown below. Pictometry will operate the system in the manner prescribed and based upon the point density chosen. These capture parameters, in conjunction with the utilization of Pictometry's Trimble R8 and 5700 GPS receivers, enable production of accurate data to create any selected derivative products. Pictometry's data collection techniques and operational parameters have been chosen to be fully compliant with FEMA and USGS standards.

Operational Configurations

	Nominal Point Spacing		
Parameter	**1.0m**	**0.7m**	**0.5m**
Flight Altitude	1800m/5900ft.	760m/2500ft.	500m/1600ft.
Point Density	1 point/m^2	2 points/m^2	4 points/m^2
Pulse Repetition Frequency	100kHz	70kHz	50kHz
Scan Angle (+/-)	16.9°	15.8°	10.1°
Scan Frequency	42.1Hz	56Hz	70.1Hz
Swath Width (raw)	1100m/3600ft.	430m/1400ft.	175m/475ft.
Overlap	30%	30%	30%
Vertical Accuracy (bare earth)	15cm $RMSE_z$	9.25cm $RMSE_z$	9.25cm $RMSE_z$
	30cm NSSDA 95%	18.2cm NSSDA 95%	18.2cm NSSDA 95%
Horizontal Accuracy*	30cm, RMSE	20cm, RMSE	20cm, RMSE
Contour Interval Supported	2ft.	1ft.	1ft.
Returns	*Up to four per pulse*		
Intensity Records	*Recorded for each return*		
**theoretical value per manufacturer's specification*			

ALTM Gemini System Specifications

Parameter	Specification
Operating altitude	80-4000 m nominal
Horizontal accuracy	1/5,500 x altitude; 1 σ
Elevation accuracy	

PRF	500 m	1000 m	2000 m	3000 m	4000 m
33 kHz	< 5 cm	< 10 cm	< 15 cm	< 20 cm	< 25 cm
50 kHz	< 5 cm	< 10 cm	< 15 cm	< 20 cm	
70 kHz	< 5 cm	< 10 cm	< 15 cm		
100 kHz	< 10 cm	< 15 cm	< 20 cm		
125 kHz	< 10 cm	< 15 cm			
143 kHz	< 15 cm	< 20 cm			
167 kHz	< 15 cm	< 35 cm @ 750 m			

Parameter	Specification
Range resolution	1 cm
Range capture	Up to 4 range measurements for each pulse, including last
Intensity capture	12-bit dynamic range for each measurement
Scan frequency	Variable; maximum 70 Hz
Scan angle	Variable from 0 to ± 25°, in increments of ±1º
Scanner product	Scan angle x scan frequency ≤ 1000
Roll compensation	5-Hz update rate Scan angle + roll compensation angle = field of view: e.g., ±20° allows ±5° compensation
Swath width	Variable; 0 to 0.93 x altitude (m)
Position and orientation system	Applanix: Optech custom POS including internal 12-channel dual frequency 2-Hz GPS receiver
Laser repetition rate *(assuming narrow beam divergence of 0.3 mrad [1/e])*	33 kHz (maximum AGL 4.0 km) 50 kHz (maximum AGL 3.0 km) 70 kHz (maximum AGL 2.5 km) 100 kHz (maximum AGL 2.0 km) 125 kHz (maximum AGL 1.6 km) 143 kHz (maximum AGL 1.4 km) 167 kHz (maximum AGL 1.2 km)
Data storage hard drives	Ruggedized removable hard drive, 10-hour continuous log time @ 100 kHz
Beam divergence	Dual divergence: 0.25 mrad (1/e) and 0.8 mrad (1/e)
Laser classification	Class 4 (US FDA 21 CFR)
Power requirements	28 V (continuous), 35 A (maximum)
Operating temperature	Control rack: +10° to 35°C Sensor head: -10° to +35°C (assuming thermal jacket)
Storage temperature	Control rack: -10°C to 50°C Sensor head: 0°C to 50°C
Humidity	0-95% non-condensing
Dimensions and weight	Control rack: 653 x 591 x 485 (mm); 55 kg Sensor head: 298 x 249 x 437 (mm); 23 kg

Data Processing

Once data has been captured, the GPS/INS data is post processed with the GPS data logged at the reference station using Applanix POSPac to generate a smoothed best-estimate trajectory (SBET). This trajectory is then applied to the raw laser data using Optech's Dash Map software package to generate the initial point cloud. During this phase, the system calibration data is also applied to provide corrections to the point cloud based on the specific characteristics of the laser scanner. Pictometry performs a full recalibration of its Gemini system approximately once every six months.

In addition to this semi-annual calibration, Pictometry calculates fine corrections on a mission by mission basis using TerraMatch software, as described in the next step.

TerraSolid - Matching and Preliminary Review

After generation of the raw point cloud data in LAS format in Dash Map, the data is imported into the TerraSolid software suite (running under Bentley's MicroStation) for matching and classification. Upon import, the data is divided into tiles for the purpose of creating more manageable data. This tiling scheme may be specified in advance by the client, if desired. Once imported to TerraSolid, blocks of data containing overlapping flight lines are selected. The data in these blocks is analyzed by TerraMatch and adjustments to the roll, pitch, heading, and scale that minimize any data misalignment between the flight lines are computed. These adjustments are then applied to the entire mission's worth of data. Data across the mission is then manually reviewed to ensure proper alignment between flight lines has been achieved. This process is then repeated for each mission; once complete, intra-sortie alignment is verified. Ultimately, the data is checked against a set of ground control points to determine overall accuracy and may be shifted uniformly to best fit the control data.

LiDAR Point Cloud of Alcatraz with Ground Classified

Classification

During this phase, points are assigned to various classes per the ASPRS Standard LiDAR point class as set forth in LAS Specification v1.3 R10 published on July 14, 2009. Pictometry will utilize the Withheld bit to identify overlap points prior to initiation of classification. Noise points – generally low points and atmospheric noise – will be identified and moved to class 7 as specified. Points representing the ground surface will be assigned to Class 2; classification of ground points is accomplished by application of a series of automatic filters followed by manual reviews to determine filter performance. A variety of filters may be utilized depending on the terrain types present in the project area, augmented by manual review and cleanup to remove outlying points.

Code	Description
1	Processed, but unclassified
2	Bare-earth ground
7	Noise (low or high; manually identified, if needed)
11	Withheld (if the Withheld bit is not implemented in processing software)

Optionally, Pictometry can extend and continue the classification process to include additional classes. Pricing for such options would vary depending upon the desired classes. Pictometry has provided pricing to include the following set of classes.

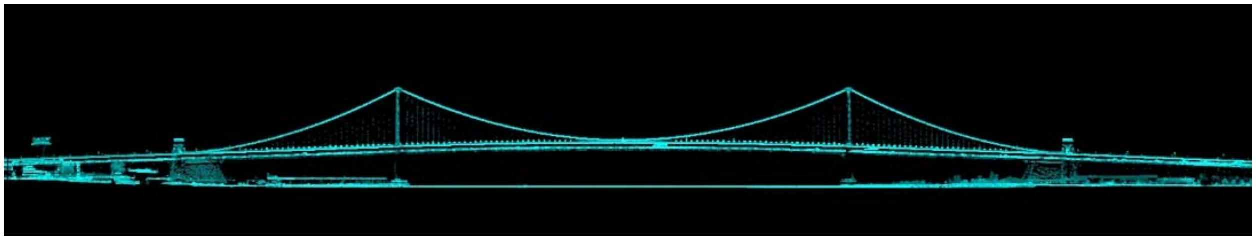
Code	Description
1	Processed, but unclassified
2	Bare-earth ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Noise (low or high; manually identified, if needed)
8	Model Key
9	Water
10	Ignored Ground (breakline proximity)
11	Withheld (if the Withheld bit is not implemented in processing software)

Metadata

Pictometry develops and delivers FGDC compliant metadata at the project level in conjunction with its LiDAR data offering.

LiDAR Data Deliverables:

- LiDAR Point Cloud Data
  - Tiled* LAS v1.2/3 files including Return Number and Intensity attribute for each return
  - Duplicate points and 95% of outliers removed
  - Ground points classified via automated methods with manual review and clean up
  - 95% of vegetation features removed
  - 98% of buildings removed
  - Buildings and vegetation only classified separately if option is selected
- Raw GPS/INS data and laser range files with supporting information
- FGDC compliant metadata
- Estimated Data Sizes (at 1.0m point spacing):
  - 10-12 GB per 100 square miles (approximate)



Elevation Data – DTM and Contours

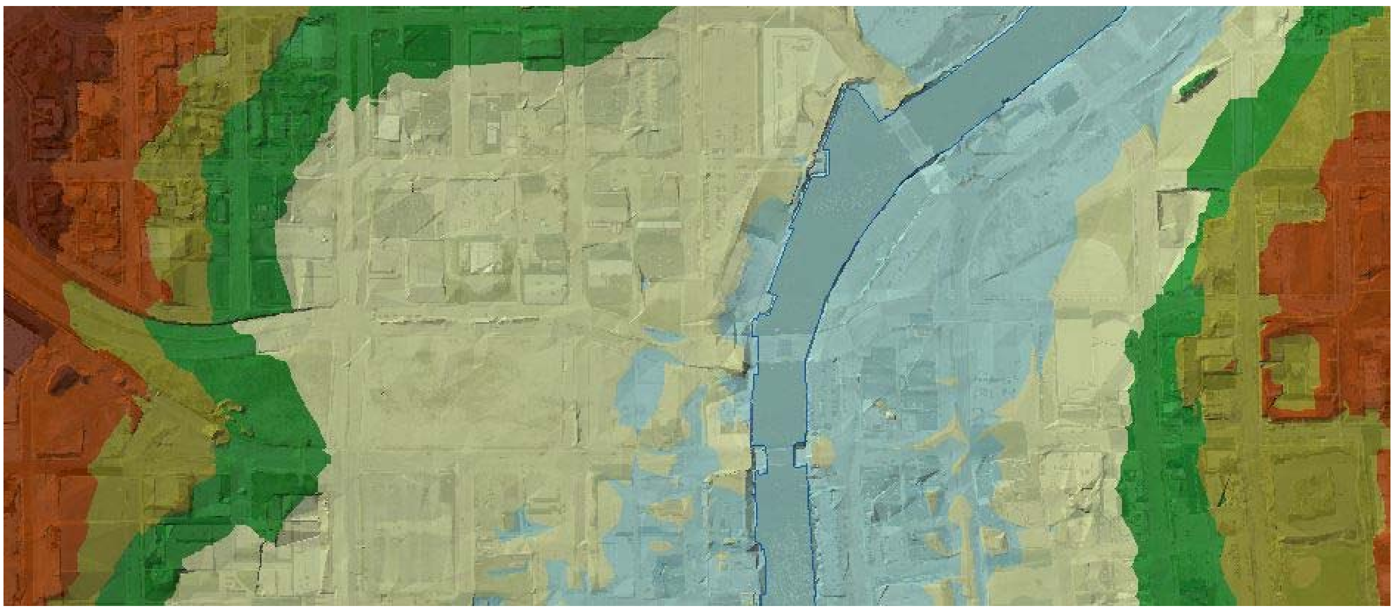
Pictometry is pleased to offer the following LiDAR derived terrain mapping products to facilitate broad based usage and democratization of LiDAR data through its partner GroundPoint Technologies.

Digital Terrain Model

DEM (Bare Earth)

ESRI Terrain

GroundPoint will convert the Bare Earth classified data contained in the LAS files to ESRI Terrain data as a fundamental step toward deriving subsequent bare earth terrain products. Developing the data in this manner will significantly enhance the delivery of data to the Customer and provide maximum flexibility for future use, updates, and edits. Standard Hydrographic Breaklines (described below) will be incorporated into all terrain deliverables. Additional breaklines may be developed and incorporated into the terrain at any time.



ESRI Terrain with Basic Hydro Breaklines over Pictometry AccuPlus Imagery

Digital Elevation Models (DEMs)

The standard DEM deliverable will be assumed to have a 10-foot grid cell size unless otherwise specified by the customer. GroundPoint will also develop a Hillshade from the DEM for visualization and cartographic mapping purposes.

Standard Hydrographic Breaklines

Breaklines are linear features that describe a change in the smoothness or continuity of a surface. As part of the baseline effort to create a DEM, GroundPoint will develop limited 3D breaklines for water feature boundaries and wide rivers and incorporate those into the ESRI Terrain data prior to generating any derived products. Hydrographic breaklines will be delineated using the LiDAR data with elevation values assigned from the LiDAR data, using best available aerial photography and the National Hydrography Dataset (NHD) as references.

Water bodies will be defined for the purposes of this task as being larger than 5m across, or greater than one (1) acre. Breaklines delineating the edge of water will be created for all such water bodies. Breaklines will not be developed for streams less than 5m across, also referred to in NHD as "single line streams".

The standard for water bodies in the USGS Specification is 100ft and two (2) acres respectively. "Hydro-flattening", as defined in the USGS Specification, will be completed at a minimum on all water bodies meeting the USGS definition. This task is intended to meet or exceed the requirements for "Hydro-flattening" in the USGS Specification.

Polygons representing flat and level water bodies (ponds, lakes), a single elevation value will be assigned to the entire polygon and/or to every bank vertex. The entire water surface edge will be at or just below the immediately surrounding terrain. For streams and rivers, breaklines indicating flat and level bank-to-bank conditions (perpendicular to the apparent flow centerline) will be created, with the gradient along the bank to follow the immediately surrounding terrain. Monotonicity will be enforced on breaklines meeting the USGS Specification. Stream and river breaklines delineating the edge of water will stop at road crossings (i.e., culvert locations).

Hillshade DEM

Bare earth LiDAR points that are within the design Nominal Point Spacing (NPS) of a breakline will be re-classified as "Ignored Ground" once the breaklines have been completed. The design NPS of a LiDAR collection is typically between 1 and 2 meters, but may be greater or less depending on the collection specifications of the project.

The identification and prioritization of additional breaklines beyond those minimally described here represents a wide range of expectations and detail depending on specific project/customer needs and intended uses. Most customized uses of breaklines are appropriate for project specific purposes, such as hydraulic modeling, construction site design or transportation engineering. As such, additional breakline development options are offered below. Additional detailed breaklines can be developed and incorporated into the terrain data at any time.

Additional Hydrographic and Slope Breaklines

GroundPoint will generate additional detailed hydrographic vector data from available digital imagery, elevation and vector GIS data. The reference data for this mapping effort will continue to be the National Hydrography Dataset (NHD). The primary method for developing these data will be to map the location of the breaklines from the LiDAR data directly using best available aerial photography as a reference for extraction of surface features. To the extent that the location or the elevation of features cannot be adequately resolved, stereo-photogrammetric methods may be used.

Additional hydrographic breaklines will be developed as follows:

Stream Centerlines: For small streams <5m identifiable from the LiDAR data and/or the Orthophotography. The reference data for these channels are commonly referred to as "single line streams" in NHD.

Edge of Water: For streams with identifiable water >5m across

Note: the edge of the water may NOT be synonymous with the edge of the stream channel depending on seasonal flow conditions in the stream.

Edge of Channel: For channels >5m across independent of the existence of visible water

Note: the edge of the channel is synonymous with the bottom of the stream bank.

Top of Bank: For all banks with clearly definable morphology 2 meters higher than the Edge of Channel.

As such, it is possible for a stream segment to have anywhere from one to six unique breaklines representing the morphology of the stream. All stream center lines and edge of water lines will be tested for monotonicity (continuous downward slope).

The level and width of water within a stream channel may vary considerably throughout the year and can significantly impact breakline vector placement as well as point classification. It should be expected that vectors delineating water may differ from vectors indicating the top and/or bottom of the stream bank. Because of temporal variations in hydrologic conditions and water levels, it should be expected that the shoreline edges associated with mean-water, low flow or other hydrologic recurrence interval may vary from those mapped by this effort. In addition, Stream Centerlines will be derived for small streams only, and will not propagate through all water bodies as part of a linear hydrologic network. Development of a stream centerline hydrologic network is considered to be an additional task.

In addition to delineating stream morphology, breaklines that delineate sharp breaks in slope on key terrain may affect the accuracy or representation of the derived surface, and the quality of resulting contours. As part of this breakline effort, GroundPoint will develop slope breaklines across the project area in addition to those described for streams above. Surface roughness and slope change analysis will be used to indicate places where breaklines are warranted, so that breaklines are extracted in places where real breaks exist in the smoothness of the terrain. Key terrain includes natural features such as ridges, valleys, bluffs, cliffs, and the tops of stream banks not otherwise included with hydrographic breaklines. Key terrain also includes man-made features such as dams, retaining walls or road cut structures or embankments that affect the slope of the overall ground surface but might not otherwise be included with transportation breaklines.

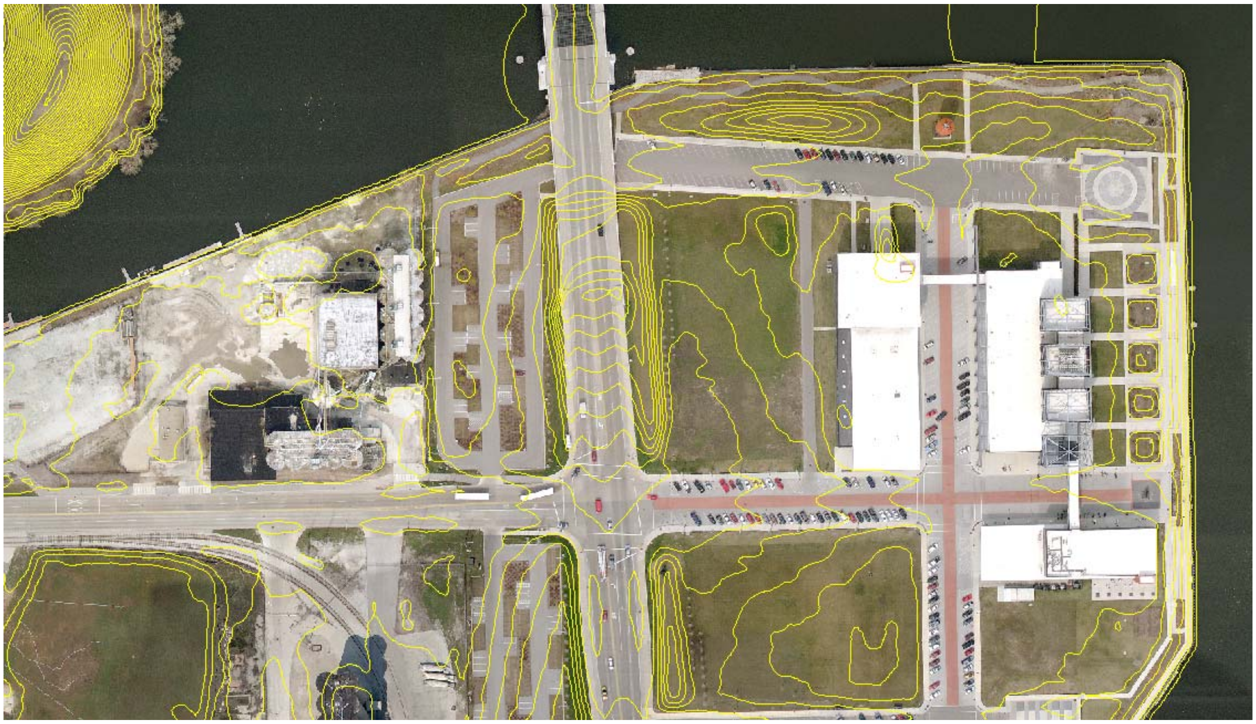
Digital Terrain Model Deliverables:

- Collection-wide point data (bare earth only) in ESRI multi-point format
- Collection-wide Terrain Data Model (bare earth) in ArcGIS TERRAIN format
- Collection-wide Digital Elevation Model (bare earth) in ArcGIS GRID format
- Collection-wide polyline files in ESRI Polyline Feature Class format
- Collection-wide Hillshade of the Bare earth DEM in ArcGIS format

Digital Contour Line File

The range of available algorithms can result in significant differences in cartographic output quality for the generation of topographic contours. Some methods more accurately represent the point data, but result in a more angular and less cartographically pleasing output. Other methods will smooth the data to varying degrees but produce a much higher quality cartographic output. The customer will be given options, based on demo data, for having their collection area contours created from smoothed data or not-smoothed data.

This task will result in vector (line) data and as such, tiling the data will be required because the vector files can be quite large. The output tiling scheme will correspond to the LiDAR tiles unless the customer requests a different tiling scheme in advance. Final tiled vector data will be seamless and free of edge effects. GroundPoint will establish elevation attributes to each contour line and identify 10, 20, and 50 ft. index contours unless otherwise specified by the Customer.



Pictometry AccuPlus Imagery with Contour Overlay

GroundPoint will derive contours, depression lines and spot elevations from the digital elevation model. Enhanced processing of the digital elevation model will be performed to facilitate creation of depression lines. All depression lines will be attributed to facilitate symbolization. All contour and depression lines will be encoded with an elevation value as an attribute.

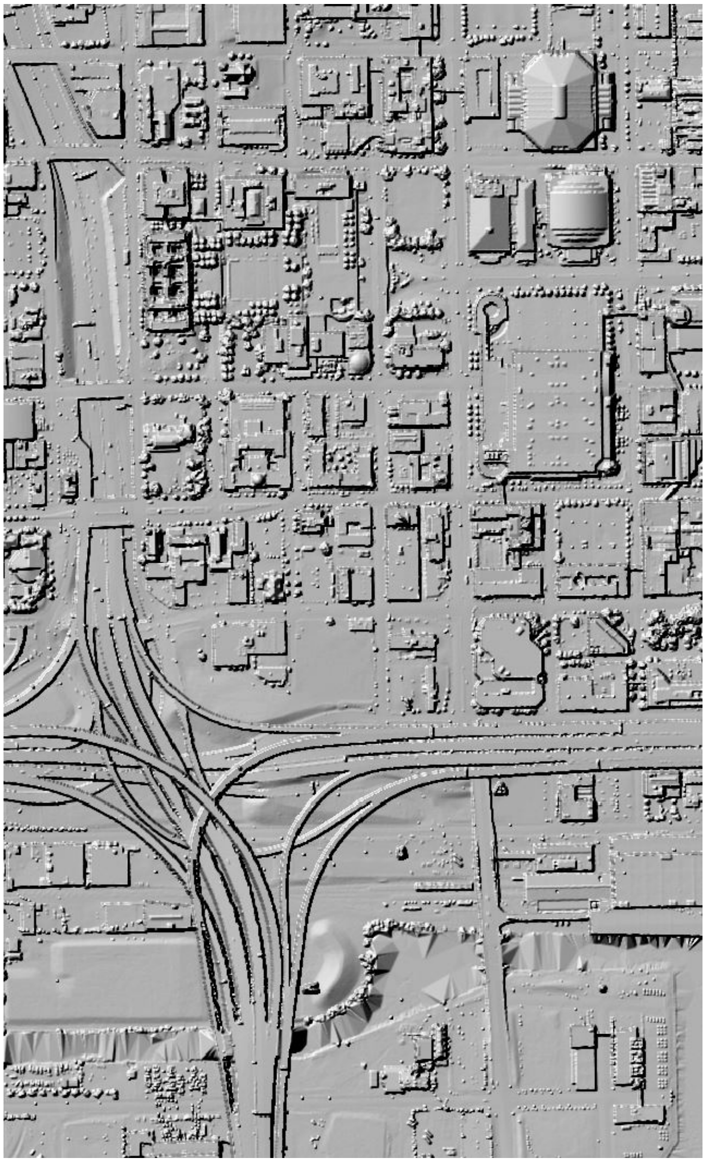
Contour Line File Deliverables:

- Tiled 1-foot or 2-foot* contour and depression line files in ESRI Polyline Feature Class format. (*NOTE: Contours will be created at maximum resolution supported by the collection as specified in Section 1.)
  - Attributed with elevation
  - Indexed to client preference

Optional Other Products

Breaklines for Transportation Features

GroundPoint will generate transportation related planimetric data representing the edge of pavement for all road features using best available imagery, elevation and vector GIS data. The data will be used as breaklines to further enforce these features in the DEM. Reference data for this will be best available public domain street centerline data and will be captured at a scale of 1:500 or better.



DSM Hillshade

Optional Breakline Deliverables:

- Collection wide polyline files in ESRI Polyline Feature Class format.

DSM (Reflective Surface)

GroundPoint will convert the data contained in the LAS files to a raster based Digital Surface Model (DSM) representing a "first surface" detected by the sensor. This first surface is represented by both bare ground in open terrain, as well as the tops of trees and buildings in areas with significant non-ground features. The elevation value of each cell in the raster dataset will represent the highest elevation value of points that fall within that cell. This surface model will not include the development or use of additional breaklines beyond that which are included with the bare earth data. Included with each DSM will be a Hillshade for visualization and cartographic purposes.

GroundPoint will also calculate and deliver a "normalized" Digital Surface Model (nDSM) where the elevation value of each cell represents the height above ground of the highest point within that cell. For both surface models, cells with no points will be interpolated based on the averaged values of nearby cells (nearest neighbor).

GroundPoint recommends including some cautionary language to all potential users of DSM data due to some of the unique characteristics of such a dataset. In some areas, a first surface model will result in objects that appear to contain a solid volume, so caution should be used when interpreting the data. GroundPoint does not recommend the use of image draping on first surface DSM models as the image stretching can be aesthetically undesirable.

DSM Deliverable:

- Collection-wide Digital Surface Model in ArcGIS Terrain format
- Collection-wide DSM and nDSM in ArcGIS GRID format with 10 foot grid cell size unless otherwise specified by the client.

Interpretive Mapping Datasets

These deliverables are intended to aid in the usage and interpretation of other Terrain Mapping products.

Void Area Mapping

GroundPoint anticipates that there will be a range of void areas on the bare earth data as a result of non-ground feature removal or absorption by water. GroundPoint will derive void area polygons from the Bare Earth point data. This ancillary deliverable is particularly useful for the Customer to have as a legacy of the collection to better understand and articulate the limitations and assumptions (i.e., interpolation) that are inherent in the derived data products. In accordance with both FEMA guidelines and the USGS Specifications, voids areas will be mapped as follows:

Data Type	Criteria
Bare Earth Data	≤10m GRID (100m^2)
First Return Data	≤8m GRID (64m^2)

FEMA guidelines indicate that void areas greater than one (1) acre occurring in the floodplains may require additional ground survey, independent of the overall collection statistics. As such GroundPoint will attribute the land cover for Bare Earth void polygons larger than one acre.

Slope Data

GroundPoint will derive percent rise and degree slope GRIDs from the DEM data developed above. The extent will be the same as the source DEM with values for slope.

Intensity Data

GroundPoint will develop intensity grids from the data contained in the LAS files. This data is particularly useful for customers to use in urban planning and hydrologic applications such as evaluating land cover types, impervious surface areas and changes in the landscape. The data will be tiled to the original LiDAR tiles, in ESRI GRID format with a grid cell size corresponding to the average post spacing of the all points LiDAR data unless otherwise specified by the Customer. GroundPoint will interpolate across voids unless the customer specifies otherwise. A raster catalog will also be included of all the tiles.

Interpretive Mapping Deliverables:

- Collection-wide Void Area polygon data in ESRI Polygon Feature Class format.
- Collection wide Slope data in ArcGIS GRID format
- Tiled Intensity data in ArcGIS Grid format unless otherwise specified.
- ESRI raster catalog of all the tiles
- Deliverables tiled to agreed-upon schema

Pictometry Licensing

In the event that Pictometry is selected to perform the services specified in this proposal, Pictometry will grant ownership to SEWRPC of orthogonal imagery produced and delivered in conjunction with this project. Additionally, Pictometry will retain co-ownership of the orthogonal imagery. Pictometry will retain ownership of the oblique imagery it produces for this project and will grant to SEWRPC a non-exclusive, non-transferable, perpetual (assuming all required payments are made to Pictometry) license to use on SEWRPC computer systems the Pictometry imagery delivered to the SEWRPC on portable digital media. SEWRPC will have the right to deploy the licensed software on an unlimited number of its users' desktops, laptops, tablet PCs, servers, PDA's and in emergency vehicles, with full Pictometry support and training at no additional cost during the initial term of the license. When a new license is signed and the images are re-flown, software support and upgrades are continued for the term of the new license; if not, there is a small optional fee for continued software support and upgrades.

To the extent the SEWRPC also purchases access to Pictometry-hosted online services, such as Connect, Pictometry will grant to the SEWRPC a non-exclusive, non-transferable, limited license to use the purchased online services for the duration of the subscription purchased.

While Pictometry requests the right to use certain SEWRPC information in the preparation and presentation of the imagery produced for this project and otherwise made available in its services, the SEWRPC's GIS data layers do not become the property of Pictometry. Because Pictometry's EFS Software, Images and other products are licensed, SEWRPC will be required to sign a Pictometry License Agreement.

Cooperative Purchasing Agreement

In addition to the SEWRPC entities participating in this project, Pictometry can structure its SEWRPC agreement as a cooperative purchasing type of agreement wherein other participating counties or municipal entities could also purchase Pictometry products pursuant to the same contract terms and pricing negotiated by the SEWRPC. This would allow any participating county to not only take advantage of Pictometry's competitive low pricing but at the same time also save on administrative time and expenses..

Pictometry Warranty

Pictometry warrants that the licensed products provided by Pictometry and installed on any authorized workstation supplied by SEWRPC pursuant to an agreement with Pictometry, will be true and usable copies as of the date of capture. Upon notice to Pictometry of any breach of that warranty, Pictometry will use its reasonable efforts to correct the problem so as to allow the licensed products to produce images and related data that are usable for the general purposes intended. If Pictometry is in breach, and has failed to cure that breach, the contract may be terminated, SEWRPC shall cease use of licensed products, purge licensed products from its computers/servers and return licensed products to Pictometry. Once Pictometry receives the products, all monies paid to Pictometry for those licensed products shall be returned to SEWRPC.

Pictometry Economic Alliance Program (EAP)

SEWRPC shall be eligible for Pictometry's disaster response Economic Alliance Program (EAP) for the term of its contract. For multi-library contracts (more than one image capture), EAP terms and conditions shown below will apply for a period of two years from the date of execution of their Pictometry agreement. Any remaining years under the agreement will be covered by the then prevailing EAP terms, as defined by Pictometry International Corp.

A. **Imagery –** with Pictometry's EAP program, SEWRPC may retain its imagery, as the EFS software and image license become perpetual at the end of the term of the license agreement.

B. **Disaster Coverage at No Additional Charge** – Pictometry will image up to 200 square miles of affected areas (as determined by Pictometry) of the events described below at no additional charge to the license fee:

- **Hurricane:** imagery of up to 200 square miles of significantly affected areas of Category II hurricanes and above. Coverage for hurricanes below this category or for areas exceeding 200 square miles will be available to active licensees at EAP rates, dependent upon resource availability.

- **Tornado:** imagery of up to 200 square miles that have been significantly impacted by Tornados with ratings of EF4 and above. Coverage for tornados below EF4 or for areas exceeding 200 square miles will be available to active licensees at EAP rates, dependent upon resource availability.

- **Terrorist:** imagery of up to 200 square miles of significant damage due to terrorist attack. Coverage beyond 200 square miles will be available to active licensees at EAP rates, dependent upon resource availability.

- **Earthquake:** imagery of up to 200 square miles of significantly affected areas with damage to critical infrastructure resulting from an Earthquake at or exceeding 6.0 on the Richter magnitude scale. Coverage for Earthquakes below 6.0 or for areas exceeding 200 square miles will be available to active licensees at EAP rates, dependent upon resource availability.

- **Tsunami**: up to 200 square miles of significantly affected areas with damage to critical infrastructure resulting from a Tsunami. Coverage for areas exceeding 200 square miles will be available to active licensees at EAP rates, dependent upon resource availability.

C. **Software – Use of Pictometry Change Analysis™ or Web Deployment of Disaster Imagery** – Pictometry's rapid disaster response program includes the use of Change Analysis™ software for ninety days from the date of delivery of any EAP imagery. The Change Analysis™ software simultaneously compares pre- and post-disaster images to aid recovery and restoration efforts. Pictometry web deployment of disaster imagery may also be available at no charge for ninety days.

Integrations

Pictometry has created interfaces and/or integrations with most major CAMA, CAD and ground level imagery partners, as well as with more than 20 of the top E-911 vendors (i.e. Intrado). In fact, Pictometry currently has 400 clients with E-911 installations in place at over 1,000 call centers (PSAPs). We also integrate with the foremost CAMA vendors – Vision Appraisal, STI/Manatron, Tyler/CLT and Colorado CustomWare. As well, Pictometry's images and software are integrated with Latitude Geographics and other GIS systems.

Pictometry is also a registered Developer Partner of Esri. Our software extensions have been designed so our users can work with oblique images within their Esri solutions. We work closely with them to continually update the extensions with support from their staff. Our oblique imagery is fully compatible with Esri's ArcMAP software (latest version 10+) through the Pictometry/Esri ArcGIS, ArcView and Arc Server. In Esri's ArcMAP, a Pictometry Toolbar is embedded, enabling the GIS user to view the oblique imagery of the area of interest. This enables the users to change directional views, employ the navigation tool, and take measurements within the image. It also allows any currently displayed feature class to be overlaid on the Pictometry imagery.

Training

Pictometry's practical training is designed to show SEWRPC's users how the Pictometry Team deliverables can enhance the ease with which they do their jobs, while increasing the results they are charged with achieving. Full, leave-behind documentation is included for the end-user and advanced training sessions. The complete training will be structured in increments noted below. As well, SEWRPC may replace training sessions below with customized online training of the same duration to suit its users' needs.

Administrator Training – One 2-3-hour session, via *GoToMeeting*
This training is designed to teach SEWRPC's IT and GIS support staffs how to install, configure and support the Pictometry Image Library and Electronic Field Study software.

End User Orientation Training – Two 3-hour sessions for up to 25 people per session
These sessions (at a SEWRPC site or web-based, as appropriate) will educate the end users to the myriad of possibilities now open to them through Pictometry's images and their own GIS data.

Advanced User Training (Hands-on) – One 2- 3-hour session for one group with up to 10 people
This training (online or through *GoToMeeting)* provides hands-on interaction with Pictometry's EFS software to end users chosen by the RPC enabling them to learn first-hand the functions covered in the Orientation Session.

Customer Support – Pictometry shall provide up to 10 hours of customer support, as needed, to those Advanced User participants identified by SEWRPC during the initial term of the agreement. Hours of support are 8:00 a.m. to 6:00 p.m. EST Mon. thru Fri. at 888-771-9714, ext. 260.

Web-based Training – SEWRPC's employees can also register at www.pictometry.com for additional, instructor-led, web-based training at any time for no additional cost.

Technical Support – Additional, ongoing technical support can be provided by Mr. Trent Pell, the Regional Technical Manager in support of SEWRPC. Mr. Pell may be reached at (812-239-9094 and trent.pell@pictometry.com.

Account Support – Account support, direction and product knowledge will be provided by Mr. Dean Larson, the District Manager in Wisconsin. Mr. Larson may be reached at (612) 201-1846 and dean.larson@pictometry.com.

Project Team

Pictometry has well-documented and carefully adhered to work flows for capturing, developing, delivering and training on the aerial imagery flown for its clients. Established departmental workflows and stepped procedures ensure the imagery is thoroughly captured, processed to the customer's expectations, delivered in the manner they seek, and their staff is trained on the images and accompanying software. The workflow for AccuPlus Is:

- Contract Administration
- Project Manager - Assumes Project Control
- Flight Planning Department – To create flight maps
- Pictometers – To calibrate the cameras
- Image Acquisition - By one or more of Pictometry's 74 planes/PentaView rigs
- Post Processing Team – Where initial data is reviewed or marked for refly
- Image Quality Review Team – Where images are inspected for errors and artifacting
- Photogrammetric Team
  - Image Selection Group - Source imagery is reviewed for inclusion in the Aerial Triangulation process
  - Aerial Triangulation (AT) Dept.
  - Ortho-rectification Dept.

- Seam line validation Team – To check and correct building and elevated structures' seam lines
- Final Mosaic Checks – Each mosaic tile is manual reviewed prior to submission for delivery
- Delivery Checks – Data prepared for delivery is carefully reviewed for completeness prior to shipment
- Images are compiled into image library in Esri ArcGIS file geodatabase format
- Delivery – Library is shipped to customer on an external USB hard drive or through Connect

- Customer Technical Services Team
  - Onsite customer training scheduled for standard ortho and oblique images and software

Project Capacity

Pictometry has sufficient available staff capacity—combined professional and technical staff resources of nearly 150 geospatial professionals—to provide timely and responsive service to meet the project schedule and delivery milestones that SEWRPC will require under this project. With our fleet of 74 airplanes and a seasoned operations staff, we are adept at capturing and processing dozens of simultaneous projects throughout the country. Our capacity for accurate, photogrammetric data capture and image library creation will easily accommodate this Fall, 2014 project without unduly burdening our procedures, resources or workflows. In fact, it is estimated that this project will represent less than 1% of our entire flight and processing capacity for the 2015 capture season.

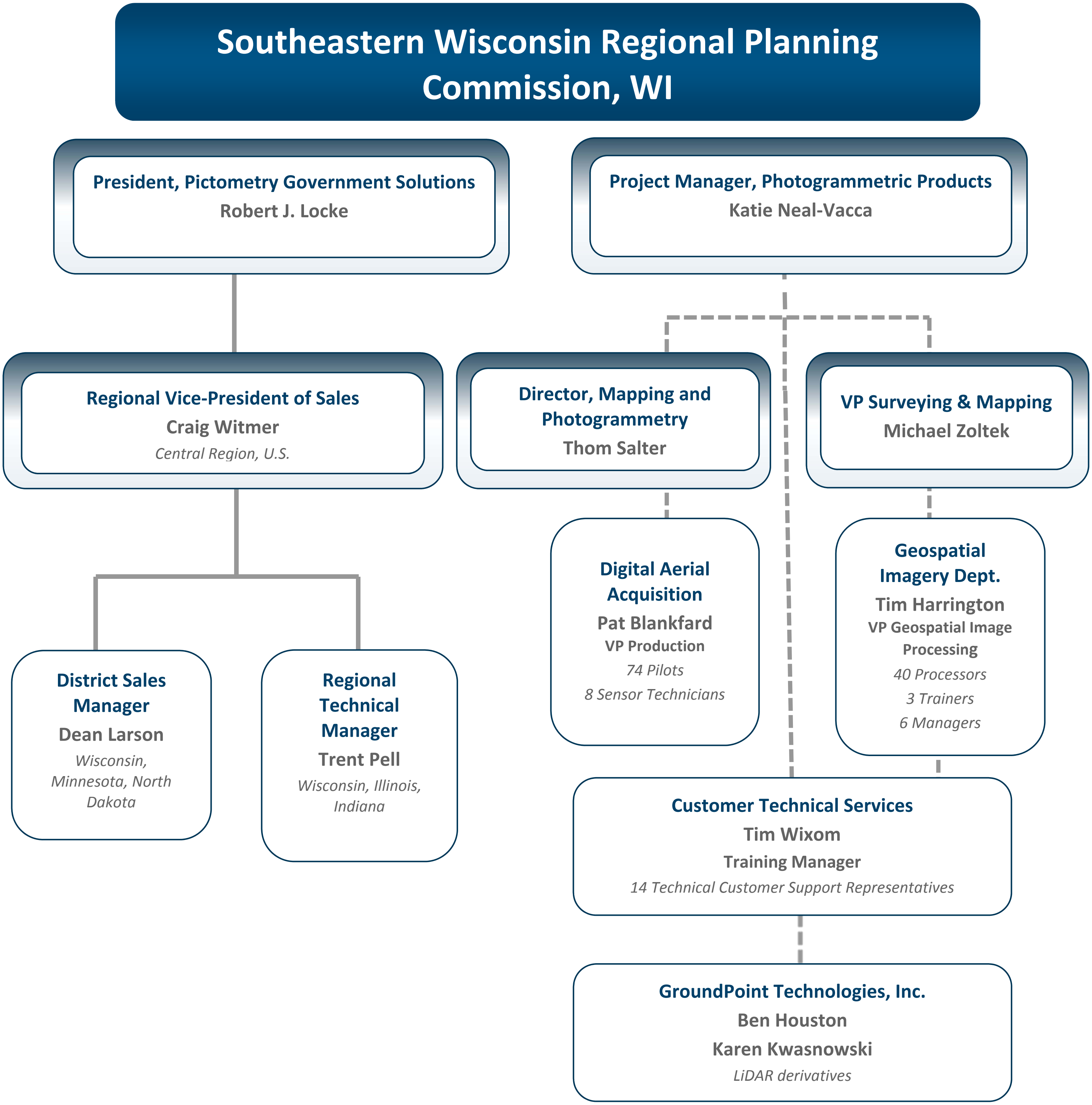
We also possess exceptional surge capability. A critical aspect of surge capability is knowing the exact status of all current work, so that needs for additional personnel can be planned in a logical manner. Detailed critical paths are formulated, with resources applied against all of the tasks in the effort. At any given time, Ms. Neal-Vacca, the Project Manager, will know exactly where this project will be in the schedule, how many resources are required, what items are critical in meeting the schedule, and what items can be moved to accommodate competing resource requirements. Where the schedule allows, all work is planned with sufficient slack time in the schedule to accommodate emergencies and surge requirements of other work.

Project Management

Ms. Katie Neal-Vacca will act as the Project Manager for this SEWRPC project. She will supported by the Production, Processing, and Customer Technical Support teams, and most importantly, by the Photogrammetry Dept. in Rochester, N.Y. As Director Photogrammetric Production, Mr. Thom Salter will monitor the direction and all aspects of the creation, quality control, and successful delivery of SEWRPC's digital aerial data project. Mr. Michael Zoltek, an ASPRS Photogrammetrist and Licensed Professional Surveyor in 19 states, including Wisconsin, will supervise the creation and quality of the ground control points and derivative products created by Houston Engineering, Inc. An organization chart of the full Pictometry team and their resumes have been noted below for SEWRPC's review.

Ms. Neal-Vacca has been the Project Manager on the majority of the hundreds of AccuPlus projects Pictometry has successfully delivered. She will closely monitor every phase of the capture, processing and delivery of SEWRPC's AccuPlus imagery and personally ship the completed library to the SEWRPC. She will dedicate as much of her time as needed to ensure the various stages proceed flawlessly and will be in frequent contact with SEWRPC throughout the project.

Pictometry Organization Chart for SEWRPC



Resumes

Pictometry International Corp.

Years' Experience
8 years

Education
BA in Geological Science, State University of New York at Geneseo, 2005

MBA Simon Graduate School of Business, University of Rochester, 2013

Katie Neal-Vacca

Project Manager, Photogrammetric Products

Summary of Qualifications:

Ms. Neal-Vacca has worked in the GIS and Aerial Imaging industries since 2005. A background in Geological Science, coupled with a Master's in Business Administration has afforded Ms. Neal-Vacca with the skills which are essential to effectively maneuver projects throughout the process in an efficient manner. In her career at Pictometry, Ms. Neal-Vacca has significant Project Management and Flight Planning experience in which keeping detailed records of aircraft deployment, flight plan assignments, image capture progress, and data receipts on projects are of the utmost importance. Pictometry prides itself on not only a core competency of Operational Excellence, but also in Product Leadership. Ms. Neal-Vacca makes it a point to ensure these attributes are experienced by Pictometry Clients.

As the Pictometry Project Manager for all Photogrammetric Products, Ms. Neal-Vacca manages the development of flight plans for data capture and oversees the quality control of all aspects of each project. She maintains daily communication with clients throughout the image capture process through phone calls, reports, and go-to-meetings (per the client's preference). Ms. Neal-Vacca also works closely with the Pictometry Customer Support team and other internal departments to ensure seamless handoffs between departments when overseeing the Photogrammetric Products, for successful project completion

Current Duties:

Ms. Neal-Vacca is Pictometry's designated point-of-contact for all AccuPlus clients and is responsible for both internal review and verification of contract requirements. She coordinates directly with clients to establish project-specific GIS data needs, prioritizes flight schedules and internal production resources based upon contract schedules and specifications. Pre-flight planning is an essential part of each Pictometry Project and Ms. Neal-Vacca handles all internal communication of deliverable requirements as well as requesting and approving flight plans. While the project is flying, Ms. Neal-Vacca monitors the progress of the flight to ensure that priorities are set properly and ground conditions are optimal per the client's requested flight window and schedule. In addition, she also approves the quality of the images, requiring that re-flies be flown if necessary.

LiDAR Project Management is also included in Ms. Neal-Vacca's responsibilities. She sets priorities for the flights as well as processing of data. In addition, Ms. Neal-Vacca coordinates production of terrain products, to ensure a deliverable which is complete and on time. Throughout the image library and AccuPlus processing, Ms. Neal-Vacca communicates priorities to the Photogrammetric Team, as well as stresses the unique details of each project to ensure correct client deliveries.

Ms. Neal-Vacca also maintains contact with clients at established intervals to provide project updates and anticipated delivery timeframes of intermediate and final deliverables. She also facilitates the relationship between Pictometry's assigned Customer Technical Services Representative and the client, to arrange for image delivery, plus software and image management training.

Project Experience:

LAR-IAC (Los Angeles Regional Area Consortium), CA

As Project Manager of the largest ortho imagery project in the United States, Ms. Neal-Vacca coordinated the capture of 4,415 square miles of 12-inch GSD and 3,309 square miles of high accuracy AccuPlus orthogonal and oblique imagery and mosaics. Throughout this process, which included the collection of oblique and orthogonal imagery that produced over 300,000 orthogonal frames), Ms. Neal-Vacca was the direct contact for both the client and subcontractors, holding weekly meetings and providing reports on flight capture throughout the imagery acquisition, followed by AT and Imager Correction Block updates.
Timeframe: April, 2008 – spring, 2011
Contract Value: $2,302,475

Orange County, FL

The 2010 Orange County, FL Image capture included 1039 square miles of 4-inch GSD AccuPlus oblique and orthogonal imagery. Throughout this project, Pictometry overcame weather issues in Florida including sunlight angle and cloud challenges to fully capture and deliver the Standard Imagery Warehouse as well as the AccuPlus Orthogonal Tiles of this densely populated county.
Timeframe: February, 2010
Contract Amount: $187,020

Franklin, OH

600 sectors of 4-inch GSD AccuPlus oblique and orthogonal imagery, mosaics, and ChangeFindr change detection service.
Role: Project Manager
Timeframe: Fall, 2011
Contract Amount: $464,199

Minot-Ward County, ND

This highly successful project captured 2,136 sectors of 12-inch GSD and 43 sectors of 4-inch GSD high accuracy AccuPlus orthogonal and oblique imagery and mosaics.
Role: Project Manager
Timeframe: Spring, 2010, with 6-inch GSD disaster imagery for the floods captured in June, 2011
Contract Value: $373,626
EAP Contract Value: $29,000

Philadelphia, PA

Consisting of 232 sectors of 4-inch and 12-inch, heavily consumed by airspace, this project has now been completed by Pictometry over 9 times, 2 of which being AccuPlus Projects. Not only does this project include very heavy airspace, but also many urban canyons. Pictometry delivered this project, which was accepted by the USGS, on time.
Timeframe: 2012
Contract Value: $175,234.50

City of Sioux Falls, SD

As an RFP win for Pictometry, Sioux Falls ran seamlessly from image and LiDAR capture to delivery of both 4-inch AccuPlus mosaics, as well as 1m LiDAR data with terrain products.
Timeframe: 2012
Contract Value: $181,723.00

Maricopa County, AZ

For Maricopa County, AZ's 2012 project, Pictometry collected oblique and orthogonal imagery at 4-inch GSD covering 1,400 square miles as well as 284 square miles of LiDAR data. This project had a very aggressive delivery timeframe requested by the customer, with a very densely populated flight area. Despite this, the project was delivered on time and on budget.
Role: Project Manager
Timeframe: 2012
Contract Amount: $679,666.48

Years' Experience
13 years

Education
B.S. Mathematics, St. John Fisher College (1999)/Associate of Science, MCC (1996)

Master of Science Applied Mathematics, RIT (in progress)

Professional Affiliations
American Society for Photogrammetry & Remote Sensing (ASPRS)

Registrations & Certifications
ASPRS Certified Photogrammetrist (CP)

Professional Surveyor & Mapper/Surveyor Photogrammetrist *(FL/VA)*

Thom S. Salter – CP, PSM, SP
Director, Mapping and Photogrammetry

Summary of Qualifications:
Mr. Salter began his Pictometry career in 2000 and has played an important role in the development of nearly every aspect of the development of the Pictometry production process. Since 2007 he has worked to develop Pictometry's mapping product offerings, including Pictometry AccuPlus, an authoritative ortho mosaic offering based on the use of Pictometry's small format camera and LiDAR based terrain mapping.

Mr. Salter served as Senior Project Manager from 2004 through 2007. During this time he managed a number of key accounts, directing flight planning activities, reporting on data capture and processing and ensuring that product quality standards were upheld. He also worked directly with Pictometry's software engineers to refine Pictometry's proprietary flight planning software for efficient simultaneous acquisition of nadir and four-way oblique imagery.

In his prior role as Senior Technical Manager, Mr. Salter developed and supervised the operation of the Pictometry camera calibration system using both lab-based and in-situ techniques. He assisted in the development of a methodology and procedures for bore sighting Pictometry's oblique and nadir imaging systems. Additionally, he established standards and procedures for post-processing of GNSS/INS data and its application to Pictometry's oblique and nadir imagery, and refined techniques for verifying and reporting the final accuracy of the products. He also worked directly with Pictometry's staff software engineers to improve Pictometry's proprietary photogrammetric software which applies exterior and interior orientation information as well as terrain data, to aerial imagery, enabling measurements to be made directly on geo-referenced oblique and orthogonal images.

Mr. Salter has extensive experience with RTK and post-processed GPS survey techniques, as well as post-processed inertially-aided airborne GPS position and orientation systems. Mr. Salter has led the sensor calibration and alignment efforts at Pictometry and also provided support for the digital camera calibration system to clients. He has technical experience with geospatial products from Esri, Trimble, Leica, and Applanix, as well as Australis digital camera calibration software.

Current Duties:
Mr. Salter directs Pictometry's Mapping and Photogrammetry Department. Departmental responsibilities include establishment of corporate policies and procedures for collection, processing, and quality assurance/control of digital aerial data, including oblique and orthogonal imagery, and LiDAR. The department is also responsible for broader aspects of Pictometry's Mapping Product offerings including project management, production, development of proposals, and expansion of Pictometry's Mapping Product offerings.

Project Experience:
Mr. Salter has extensive experience with the direction and performance of all aspects of digital aerial data projects, including project management, flight planning, GNSS/INS post-processing, aerial triangulation, and ortho production, and final review and approval (QA/QC) of all project deliverables on large projects comprising over 30,000 square miles of oblique and orthogonal imagery.

County of Los Angeles, CA (2008/2011)

This project included the collection of approximately 300,000 nadir image frames and used over 600 ground control points in the 17 aerial triangulation (AT) blocks adjusted for this project. It is one of the largest aerial triangulation (in terms of total frames involved) projects ever completed. Mr. Salter served as production manager, as well as project manager for the ortho-mosaic portion of the project, and later as Project Director. Along with a team under his supervision, he worked to develop the methodology and technical procedures necessary to complete this project and developed a project plan which determined ground control requirements, an aerial triangulation block layout schema, and restrictions on data capture parameters. He coordinated with both the customer and subcontractors to create a final acceptance criteria document, including aerial triangulation statistical requirements. The project deliverables consisted of a tiled seamless ortho-mosaic provided in GeoTIFF format and an area-wide mosaic in MrSID format along with FGDC compliant metadata. ~4000 square miles

Department of Homeland Security (DHS), State of Readiness Demonstration (2013)

This project consisted of the collection and rapid production and deployment of orthogonal imagery to serve as a demonstration of capabilities to produce and deploy oblique and orthogonal imagery within a 48 hour window of 'go-time.' Mr. Salter directed the orthogonal imagery acquisition and production for this project. Along with a team under his supervision he developed and executed an accelerated workflow to perform aerial triangulation, orthorectification, mosaicking and delivery of 60 square miles of orthogonal imagery within 24 hours of receipt of data at the production facility. Pictometry served as a sub-contractor to Dewberry for this project.

City of Philadelphia, PA (2009/2011)

This project consisted primarily of the creation of a city-wide seamless ortho-mosaic product and a city-wide LiDAR dataset. Mr. Salter served as production manager and, along with a team under his supervision, developed and executed a project plan, including final product accuracy specifications, and oversight of the acquisition of ground control by a licensed sub-consultant sufficient to support the project specifications. A team under his supervision performed analytic aerial triangulation and used Inpho's OrthoMaster and OrthoVista to perform ortho rectification and mosaicking. Mr. Salter reviewed and approved the mosaicked imagery prior to delivery to the customer to verify that the project specifications had been met. A team under his supervision processed the raw LiDAR data and associated POS data to produce a fully calibrated and matched LiDAR point cloud. The team also performed classification of ground points including a manual review, and produced a gridded DEM. The project deliverables consisted of a tiled seamless ortho-mosaic provided in GeoTIFF format, an area-wide mosaic in ECW format, a LiDAR point cloud with ground points classified in LAS format, and a gridded DEM with basic hydro enforcement. FGDC compliant metadata was also produced and delivered. ~160 square miles

County of Milwaukee, WI (2010/2013)

This project involved the acquisition of LiDAR data to support the generation of 1-foot contours and acquisition and production of a 6-inch GSD county-wide ortho-mosaic from over 25,000 imagery frames. Mr. Salter directed Project Management and Production efforts and along with a team under his direct supervision, he developed and executed a project plan, including final product accuracy specifications. Mr. Salter also coordinated with the licensed professional surveyor to ensure field procedures used to collect and establish control point coordinates were sufficient to supply the accuracy required to support the AT process and the FEMA Accuracy Assessment. He also validated the quality of the GNSS/INS solutions and AT results. Mr. Salter reviewed and approved the mosaicked imagery prior to delivery to the customer to verify that the project specifications had been met. Project deliverables consisted of 269 square miles of seamless ortho-mosaicked imagery at 6-inch GSD, LiDAR data, a hydro enforce DEM, and FGDC compliant metadata.

County of Solano, CA (2008)

This project consisted of capture of 948 square miles of orthogonal imagery (244 square miles at 4-inch GSD, 704 square miles at 8-inch GSD) covering the County of Solano, CA and surrounding area. Mr. Salter served as production manager and, along with a team under his supervision, developed and executed a project plan, including final product accuracy specifications. The plan included the layout of flight plans and evaluation of existing ground control network, and confirmation of its ability to support the required analytical aerial triangulation (AT). Additionally, due to the size of the project, an AT block schema was developed. The flight lines, including cross lines, were planned with respect to the ground control in order to ensure a strong geometric basis for the AT solution. Mr. Salter validated the quality of the GPS/INS solutions and the team under his supervision performed the AT. Mr. Salter reviewed and approved the AT results prior to orthorectification. A LiDAR-derived surface model was used to support the ortho-rectification. The project deliverables consisted of a tiled seamless ortho-mosaic in GeoTIFF format and an area wide mosaic in ECW format along with FGDC compliant metadata were also delivered. This project was accepted into the USGS National Geospatial Program (National Map).

Years' Experience
23 years

Education
B.S. Surveying & Mapping, University of Florida (1993) / Associate of Arts, University of Florida (1990)

United States Army Infantry School, Fort Benning, GA (1988)

Professional Affiliations
American Society for Photogrammetry & Remote Sensing (ASPRS)
Florida Surveying & Mapping Society (FSMS)
New York State Society of Professional Land Surveyors (NYSASPLS)
National Society of Professional Surveyors (NSPS),
New York State GIS Association (NYSGIS)

Registrations & Certifications
State Licensed Land Surveyor Photogrammetrist (AL, AZ, CA, CT, FL, GA, ID, LA, MS, NC, NV, NM, NY, ND, OR, SC, SD, TN, TX, USVI, WI, WV)

Certified Federal Surveyor (CFedS)

Nevada State Water Right Surveyor

NCEES Model Law Surveyor Geographic Information System Professional (GISP)

ASPRS Certified Photogrammetrist (CP)

Michael J. Zoltek, CP, LS, CFedS, GISP
Vice President of Surveying & Mapping

Summary of Qualifications:

Mr. Zoltek is experienced since 1990 in a wide variety of public and private sector Surveying and Photogrammetric projects He is adept in the coordination and supervision of large scale photogrammetric, LiDAR and land surveying projects including the establishment and approval of the technical procedures used in the collection, processing and certification of data. He has extensive experience working in various districts of the Florida Department of Transportation, the preparation of "survey" control layers for Geographic Information Systems databases, creation of composite mapping products including digital databases and certified maps, legal descriptions, Design Surveys, Transportation Corridor Surveys, Right of Way Control Surveys, Right of Way Maps, Design Surveys, Construction Layout Surveys, Jurisdiction Line Surveys, Mean High Water Line Surveys, and Mean High Water Tide Studies

Mr. Zoltek has served as an expert witness on boundary-related litigation cases and has been a guest lecturer at both the University of Florida and Troy University Geomatics Programs. Mr. Zoltek has also been a presenter of professional technical seminars for various professional organizations and user groups.

Current Duties:

Mr. Zoltek is Surveyor/Photogrammetrist in responsible charge of setting corporate policies and procedures used to collect and verify oblique and orthogonal aerial imagery and ground control information. His duties include: the establishment and implementation of company-wide QA/QC procedures for individual surveying and mapping tasks and overall project requirements; establishing and/or approving the technical procedures used in the collection and processing of surveying and mapping data; supervising staff performing field collection and office processing of field collected data; post-processing GPS survey data of control fields, base stations and Ground Control Points (GCPs) to required support imagery and LiDAR projects; planning GCP locations and reviewing/approving flight plans for ortho-imagery projects; reviewing/approving Aerotriangulation (AT) bundle adjustments; report preparation and certifying accuracies of collected data; reviewing independent accuracy assessments and certifications of Photogrammetric data used by the company and its clients; and performing QA/QC reviews on digital data sets prepared by Pictometry for its clients. Mr. Zoltek also supports staff collecting terrestrial LiDAR data for transportation corridor surveys including the supervision and/or review of collected data and the preparation and/or review of certifications and accuracy statements prepared for Pictometry projects. He coordinates project schedules and task assignments and reviews and approves tasks performed by professional and technical sub-consultants.

Project Experience:

Mr. Zoltek has coordinated the collection of survey ground control points, prepared accuracy assessment reports, performed QA/QC reviews and/or approved the results of AT bundle adjustments for over 200 oblique and/or orthogonal imagery projects as well as multiple LiDAR projects throughout the United States and Canada.

County of Los Angeles, CA

This project included the collection of oblique and orthogonal imagery that produced over 300,000 orthogonal frames of 4-inch and 12-inch Ground Sample Distance (GSD) imagery covering the entirety of Los Angeles County, California. For this project, Mr. Zoltek established positions of ground control (photo-ID points and/or aerial target) to support aerial triangulation (AT) of orthogonal imagery frames, coordinated and reviewed results of survey ground control points as collected by licensed Surveyor sub-consultant, reviewed and approved the results of AT bundle adjustments of 26 individual AT blocks. He also coordinated with the County's QA/QC sub-consultant to ensure independent reviews were satisfactorily completed. Deliverables for this project included exterior orientation data, camera models and individual imagery frames for use in creating stereo-pairs for photogrammetric compilation and ortho-mosaic production by a sub-consultant. ~4000 square miles

USMC Military Bases, SE United States

This project included the collection of oblique and orthogonal imagery over eleven (11) Marine Corp bases throughout the southeast United States collected at 3-inch (7.5cm) Ground Sample Distance (GSD). For this project, Mr. Zoltek established positions of ground control (photo-ID points and/or aerial target) to support aerial triangulation (AT) of orthogonal imagery frames and LiDAR collection performed by another sub-consultant, coordinated and reviewed results of survey ground control points as collected by licensed Surveyor sub-consultant, and reviewed and approved the results of AT bundle adjustments of 13 individual AT blocks. Deliverables for this project included seamless Pictometry standard Oblique and Orthogonal image frames, fully orthorectified orthomosaic image tiles and an Imagery Report delineating procedures used, GPS/INS post processing statistics, and aerial triangulation results. ~321 square miles

Property Appraiser, Santa Rosa County, FL

This project included the collection of 12-inch Ground Sample Distance (GSD) orthogonal and oblique imagery and the creation of certified orthomosaic imagery suitable for use by the County's GIS department and for acceptance into the USGS National Geospatial Program (National Map). Mr. Zoltek established the positions of ground control (photo-ID points and/or aerial target) required to support aerial triangulation of imagery frames, coordinated and reviewed results of survey ground control points as collected by a licensed surveyor sub-consultant, reviewed and approved the aerotriangulation (AT) bundle adjustments; and prepared accuracy assessment reports and certifications for the final ortho-mosaic product. He also worked with Pictometry staff performing image compilation, edits and adjustments. Deliverables for this project included seamless orthomosaic image tiles of the county and a signed/sealed Surveyor's Report delineating procedures used, GPS/INS post processing statistics, aerial triangulation results, NSSDA accuracy assessment of imagery and horizontal accuracy certification. ~1000 square miles

Public Service Electric & Gas Company (PSEG), NJ

PSEG contracted with Pictometry to capture LIDAR data together with orthogonal and oblique imagery for and to provide North American Electric Reliability Corporation (NERC) compliant Vegetation analysis Vegetation Management Analysis Reports and PLS-CADD Plan-Profile drawings as full cad deliverables to support Transmission Line analysis for approximately 445 linear miles of electrical transmission line corridor within the state of New Jersey. Mr. Zoltek acted as the project manager and was responsible for the completion of tasks outlined in the scope of services. He coordinated directly with the Engineer of Record (EOR) to verify that the technical requirements for North American Electric Reliability Corporation (NERC) data capture were met. Mr. Zoltek planned ground control point locations required to support imagery and LiDAR data collection, as well as the location of weather station units used to capture atmospheric data, and the compilation and delivery of said data to the EOR. Mr. Zoltek was also responsible for technical and administrative coordination with PSEG and the compilation of project deliverables. ~450 square miles

Mid Bay Bridge Authority, Okaloosa County, FL

This project encompassed an 11-mile corridor of proposed new roadway through Eglin Air Force Base (AFB), Florida. Mr. Zoltek established the technical specifications and QA/QC procedures required to adequately perform a topographic survey with LiDAR that was capable of supporting the accuracy design requirements of 11 miles of new roadway through unimproved terrain. Mr. Zoltek coordinated directly with representatives from Eglin AFB to obtain access and security clearance to perform ground surveys in sensitive military areas and also coordinated with the Eglin AFB Real Property Division to research data required for existing easements and rights of way. Mr. Zoltek also: supervised and approved all Design Surveying Services; established new Survey control (via Static GPS Network); supervised field verification of aerial photography and LIDAR data collection; coordinated all conventional, photogrammetric and LiDAR related surveying tasks with the Engineer of Record (EOR); supervised and directed field crews; performed office computations; and prepared a Surveyor's report, accuracy assessment and certification of vertical accuracies of the LiDAR data used to create the project DTM and horizontal positions of planimetric features.

Years' Experience
13 Years

Education
University of Maryland (1979)

Bachelor of Arts in Business Management

Pat Blankfard
Vice-President of Production

Summary of Qualifications:

Mr. Blankfard's role is a huge one to Pictometry. He is responsible for the overall coordination of our 72 planes and pilots that capture every client's images. He has been the production coordinator for every imagery project Pictometry has ever implemented. Mr. Blankfard develops the pilot and aircraft schedules, creates the flight plans, works closely with our weather forecasting partners, is in daily contact with all the pilots, and coordinates any reflys. His team of Pictometers maintains all the planes and regularly conducts the calibrations on the five PentaView cameras to ensure they work to perfection throughout the year. His experienced Flight Managers create the flight plans for every capture, and apply for and track the FTC permits, FRZ's and other registrations needed to give Pictometry's planes clearance at the hundreds of airports across the nation. In fact, Mr. Blankfard was instrumental in getting Pictometry awarded P56 status (flight approval in the restricted area) in the District of Columbia.

Mr. Blankfard has especially become adept at working around the adverse weather conditions that affect all areas of the country. He is in constant communication with Pictometry's weather partner, the pilots and the regional airports to gauge the wind, sunlight, cloud, precipitation and other conditions that can affect each flight. With his 23+ years' experience in the air express industry, and the 13 years at Pictometry, Mr. Blankfard's skill, experience and temperament are uniquely qualified to successfully handle this ever challenging position.

Project Experience:

LAR-IAC, County of Los Angeles, CA
Role on Project: Flight Capture Supervisor and Coordinator
Captures in 2008, 2010 and 2011

Mr. Blankfard had his hands full in scheduling the aircraft and pilots to capture the 4,216 square miles of 4-inch GSD high accuracy AccuPlus orthogonal and oblique imagery for this project. Obstacles include low fog and smog and some altitude challenges. Mr. Blankfard worked closely with Pictometry's partners to ensure that high quality imagery was captured so they could orthorectify and triangulate the orthogonal imagery. The first project represented what is believed to be the single largest orthogonal imagery project in history, based on the square miles of the area, the high number of images captured and the number of source frames; nearly 300,000 frames were triangulated and ortho-rectified to create the final ortho mosaic.

Philadelphia, PA -AccuPlus, High Accuracy Image Capture
Role on Project: Flight Capture Supervisor and Coordinator
Captures in 2003, 2004, 2005, 2006, 2008, 2009, 2010 and 2011

This capture was the largest AccuPlus project that Pictometry had done at the time. AccuPlus involves many more flight lines, lower flight heights, stricter accuracy requirements, and increased coordination with the FAA and ATC. Mr. Blankfard coordinated the aircraft and pilots to capture over 191 square miles of 4- and 12-inch GSD oblique and orthogonal images. He worked closely with Pictometry's Photogrammetry Dept. to coordinate the LiDAR flights that needed to be scheduled nearly simultaneously with the imagery flights.

Lee County, FL, Standard Aerial Image Capture
Role on Project: Flight Capture Supervisor and Coordinator
Captures in 2001, 2003, 2006 and 2008

The recurring image captures for Lee County, FL are indicative of the day-to-day work that Mr. Blankfard and his crew coordinate. The initial image captures were for standard three-way 12-inch GSD and five-way 6-inch GSD orthogonal and oblique imagery. Lee County updated its most recent image capture to Pictometry's high accuracy, AccuPlus product at 4-inch GSD. Mr. Blankfard is well experienced with the Air Traffic Control organizations in Florida and the image capture obstacles due to artifacts that bright sunlight can have on images. Mr. Blankfard's team has an excellent record of low reflys because of the due diligence done for each flight.

Years' Experience
15 years

Education
Monroe Community College

Associate Degree in Visual Communication

Tim Harrington
Vice President of Geospatial Image Processing

Summary of Qualifications:

Mr. Harrington has over 15 years of experience in the processing industry. At Pictometry, he manages two daily staffs that take the flown images and ready them into usable libraries for our customers. He and his Processors manage the fleet of computers, automated network systems and processors that orthorectify the images and calibrates them to Pictometry's stringent mapping performance standards. Under Mr. Harrington's direction, the processing team overlay the customers' GIS data onto the images and projects them in the datum and projection specified. His staff keeps inventory of the received projects and images, and records their progress through development and final QA/QC controls. They ensure that the image library is calibrated, color-balanced and resolved to Pictometry's high standards then passed to our Customer Technical Services Dept. for packaging of, delivery to and training of the Pictometry clients.

Project Experience:

State of Louisiana, Disaster Recovery of Hurricane Katrina Damage
Role on Project: Director of Processing
August, 2005

Mr. Harrington's teams handled the immediate influx of hard drives and images from this emergency capture project. He supplied daily reports to both Pictometry's management and the Federal, State and City emergency organizations of the captured sorties, managed the Processing staff and additional shifts needed to process the imagery, and ensured that the imagery was quickly loaded into POL for mass online content availability.

City of Philadelphia and the USGS, Digital Aerial Imagery and LiDAR Project
Role on Project: Director of Processing
Captures in 2003, 2004, 2005, 2006, 2008, 2009, 2010 and 2011

Mr. Harrington and his Processing teams touch every image that comes into Pictometry. This Philadelphia project consisted of high-accuracy oblique and ortho-imagery, as well as LiDAR data. Both of the aerial imagery and LiDAR datasets were captured in Spring of 2010 and covered an area of approximately 163 square miles. The aerial imagery was collected at 4-inch GSD. Mr. Harrington's team processed *all* the imagery, geo-referencing the oblique imagery with the LiDAR data. It then handed it off to Pictometry's Photogrammetric Dept. to create the custom AccuPlus mosaics. The City of Philadelphia received all orthogonal, oblique and LiDAR deliverables and the orthogonal imagery was also delivered to the USGS.

Westchester County, NY, Digital Oblique and Orthogonal Aerial Imagery
Role on Project: Director of Processing Fall, 2010

Mr. Harrington worked collaboratively with Pictometry's processors to expedite the 41 software processes that turned the raw orthogonal and oblique image data of the 45 municipalities in Westchester County into clear and concise images. 542 square miles of imagery were captured at 4-inch GSD. Mr. Harrington also had to work with Pictometry's street level partner to integrate that imagery into the delivered library.

GroundPoint Technologies, LLC

GroundPoint Technologies, LLC is a company formed in early 2009 to provide quality LiDAR data services, as well as expanded geospatial data solutions, to both private and government sector customers. GroundPoint Technologies, LLC was formed in New York State as a small, Woman-Owned Enterprise for state, local and federal procurement purposes. The Company principals have a combined history and experience that spans federal, state and local government programs, as well as consulting work that's been done in both the private and non-profit sectors. In addition, GroundPoint Technologies, LLC has strong business partnerships that allow it to offer the right mix of production capacity and technology solutions for each project.

What We Do

GroundPoint Technologies LLC was formed primarily to provide quality LiDAR data services. As such, primary activities include but are not limited to:

- Independent LiDAR Collection QC and Accuracy Assessment [1]
- ESRI Terrain Development [2]
- Bare Earth Digital Elevation Models [2]
- First Surface Digital Surface Models
- Contour Development [2]
- Slope Analysis, Void Area Analysis, Intensity Grids
- Building Footprint Extraction
- Forested Area Extraction
- Three Dimensional Visualizations

1-The standards for such reviews are codified in the FEMA document "Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix A: Guidance for Aerial Mapping and Surveying, April 2003" (FEMA Guidelines) http://www.fema.gov/pdf/fhm/frm_gsaa.pdf

2-Terrain products can include a range of breakline development options to include either 2-D or 3-D breaklines to support hydro enforcement and improved contour accuracy.

Through a partnership with the **Institute for the Application of Geospatial Technology** (IAGT), GroundPoint Technologies can offer customers a stand-alone solution for three dimensional visualizations by draping the most recent aerial photography over high resolution LiDAR terrain data in a freely deployable and distributable viewer. The solution is capable of integrating GIS vector data, and clients can choose to host the resulting visualization files over the internet. Interested parties can download the free viewer and see a sample dataset at www.iagt.org/terrain.

In addition, GroundPoint Technologies offers a full range of geospatial data processing and analysis capabilities that include remote sensing image analysis, raster based modeling and application development services.

Benjamin H. Houston, P.E., PMP, GISP
Chief Executive Officer

Mr. Houston has 20 years' experience in topographic engineering and related engineering and mapping activities. He is co-founder of GroundPoint Technologies currently leads business development and strategic planning.

Mr. Houston spent 12 years as an Army Officer, first as a Topographic Engineer in the US Army Corps of Engineers and later as a Staff Officer, Public Health Engineer, and Special Operations Team Leader with the US Army Special Operations Command. He is a graduate of the US Army Combined Arms Services Staff School, the Defense Mapping Agency, and the JFK Special Warfare Center and School. Mr. Houston has also held various positions as an engineer and GIS analyst with both for-profit and non-profit consulting companies, and has held positions in various local government agencies at the County level including the Department of Planning, Department of Public Works, and the Department of Health. He is a licensed Professional Engineer in the State of New York and has a broad background in public health engineering, public utilities infrastructure, and storm water management. Mr. Houston specializes in raster based terrain analysis and GIS data integration. He is a certified Project Management Professional by the Project Management Institute (PMI) and a certified GIS Professional by the GIS Certification Institute (GISCI). He is a past Vice-President of the Genesee/Finger Lakes Region Geographic Information System Special Interest Group, and is currently an active member of the New York State GIS Association, the American Society for Photogrammetry and Remote Sensing (ASPRS), and the American Water Resources Association (AWRA).

Mr. Houston's background enables him to uniquely understand local government user needs, and how to successfully apply advanced terrain mapping and GIS technologies to achieve project success. He has also been the author of a number of publications and presentations over the past 10 years.

Colorado School of Mines, Bachelor of Science in Geological Engineering
North Carolina State University, Master of Science in Earth Science

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Karen Kwasnowski, GISP
Chief Technical Officer
University of Rochester, Bachelor of Science in Earth Science

Mrs. Kwasnowski has 15 years' experience as a senior GIS technologist with a broad range of LiDAR and other remote sensing and geospatial project experience. She is co-founder of GroundPoint Technologies and currently oversees all of GroundPoint's technical production. She has successfully lead LiDAR and GIS projects for a range of government agencies at the County and State level, and for Federal Agencies such as the National Aeronautics and Space Administration (NASA). Her specialties include quality control and accuracy assessment of LiDAR data and the development of terrain products for GIS integration.

Mrs. Kwasnowski's career began with the New York State Technology Enterprise Center (NYSTEC) as an incubator for high tech industries in New York, and continued as a senior technologist and project manager with the Institute for the Application of Geospatial Technology (IAGT), a non-profit institute dedicated to the transfer of geospatial technologies for public benefit.

University of Rochester, Bachelor of Science in Earth Science

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Client References

Pictometry International Corp.

Milwaukee, WI
Bill Shaw, GIS Supervisor
2711 W. Wells St., 4th Floor
Milwaukee, WI 53208
Phone: (414) 278-2176
E-Mail: bshaw@milwcnty.com

Pictometry Services: LiDAR (Contours, DEM, DSM, Hydro Enforced Break lines, Voids and Slopes), AccuPlus Oblique and Orthogonal Imagery, EFS Software, Connect
Departments Using Pictometry's Services: GIS, Business & Community Development, Planning, Engineering, Assessing, Police, Fire

Pictometry Customer: Since 2006
Land Area: 242 sq. miles
LiDAR Land Area: 242 sq. miles
LiDAR Point Spacing: 0.7m point spacing
Start/Delivery Dates: Spring, 2010
Contract Value: $207,000
Pictometry Connect: Subscribed to Connect on 9/23/2013

City of Racine, WI
Mark Yehlen, P.E.
Commissioner of Public Works
730 Washington Avenue
Racine, WI 53403
Phone: 262-636-9121
E-Mail: mark.yehlen@cityofracine.org

City Departments Using Pictometry's Services: GIS, Assessor, Public Works, Police, Fire, Planning
Pictometry Services: AccuPlus Orthogonal and Oblique imagery, LiDAR, DEM, Contours, Connect, ArcGIS

Pictometry Customer: Since 2013
Land Area: 25 sq. mi.
Products: 25 sq. mi. of 3-inch GSD AccuPlus oblique/orthogonal imagery
Start/Delivery Dates: Spring, 2013
Contract Value: $46,000.00

Nebraska-Iowa Regional Ortho Consortium (NIROC), NE
Project Sponsor – MAPA – Metropolitan Area Planning Agency
Mike Schonlau, GIS Coordinator
Douglas County/Omaha
1819 Farnam Street - 402
Omaha, NE 68183
Phone: (402) 444-3982
E-Mail: mschonlau@douglascounty-ne.gov

Departments Using Pictometry's Services: GIS Department, Planning, Public Safety, Public Works, Assessment
Additional Applications: Standard Oblique/Orthogonal Image Capture, E-911 Integration, CAMA Integration, ESRI Integrations

Pictometry Customer:	Since 2010
Land Area:	4,766 mi^2
Products:	4,766 mi^2 of 4 – way, 9-inch GSD oblique/ortho imagery
	2,080 mi^2 of 4 – way, 3-inch GSD oblique/ortho imagery
Flight Dates:	March 2010, March 2013
Contract Value:	$1,087,000

Sioux Falls, SD
Shannon Ausen, Civil Engineering
224 W. Ninth St.
Sioux Falls, SD 57104
Phone: 605-367-8601
E-Mail: sausen@siouxfalls.org

City Departments Using Pictometry's Services: Attorneys, Building Services, Community Development, Engineering, Fire, GIS, Health, IT, Landfill, Lights, Metro, Parks, Planning, Police, Public Works, Risk Management, City DOT, Streets, Traffic, Water Maintenance, Minnehaha County
Pictometry Services: AccuPlus Oblique & Orthogonal Imagery, LiDAR at 1.0 meter point spacing, DEM, DTM, 2-ft. contours, Self-Hosted Pictometry Online, ChangeFindr, Sketch, Building Footprints, ArcGIS

Pictometry Customer:	Since 2012
Land Area:	218 sq. miles
Products:	218 mi^2 of 4-inch GSD of AccuPlus oblique/ortho imagery
Start/Delivery Dates:	Spring, 2012
Contract Value:	$213,445

Los Angeles County, CA (LAR-IAC)
Mark Greninger, Chief Geographic Information Officer
Chief Information Office
World Trade Center
350 S. Figueroa St, Suite 188
Los Angeles, CA 90071
Phone: (213) 253-5624
E-Mail: mgreninger@cio.lacounty.gov

Departments Using Pictometry's Services: Assessment, GIS, Agricultural Commission, CEO, Emergency Management, Animal Control, Beaches and Harbors, Family Services, Senior Services, Health Services, Mental

Health Services, Parks and Recreation, Public Health, Social Services, Public Works, Regional Planning, Fire, Internal Services, Probation, Public Utility, Registrar/County Clerk and Sheriff's Depts.
Additional Applications: EFS software, ArcSDE support, AccuPlus, ChangeFindr, Building Outlines, POL, Connect Platform, IPA, and Early Access

Pictometry Customer: Since 2003
Land area: 4,216 mi^2
Products: Community Level: 4,216 mi^2 of 3 – way oblique/ortho imagery
Neighborhood Level: 3,167 mi^2 5 – way oblique/ortho imagery
Start/Stop Dates: (2003, 2004, 2006, 2008, 2010, 2011 and 2013)
Contract Value: $2,061,095.85 (2013 - four-year deal with up to 12 years of renewals)

The 2008 project represented what is believed to be the single largest orthogonal imagery project in history, based on the number of source frames; nearly 300,000 frames were triangulated and ortho-rectified to create the final ortho mosaic.

GroundPoint Technologies, LLC

Project Name: New York City DEP Hydrography and Topographic Mapping
Period of Project: 2010-2012
Approximate Size of Project: ~$1.2M

Project Summary:
GroundPoint Technologies provided primary support to the completion and delivery of 2500 square miles of LiDAR based hydrography, contours, and digital elevation data to the New York City Department of Environmental Protection covering the watersheds that provide drinking water daily to over 10 million people. The watersheds, located in the Catskill Mountains to the west and in the more heavily populated Westchester and Putnam Counties to the east, support the single largest unfiltered drinking water supply in the nation. As such the City of New York relies heavily on accurate hydrography data for implementing and maintaining water quality protection programs designed to ensure the long term economic viability of the water supply. This project was a multi-year effort lead by GroundPoint in partnership with the State University of New York. The partnership was developed, in part, to implement a new mapping specification for capturing hydrographic data from airborne LiDAR data and high resolution aerial photography Terrain data for the entire watershed was hydro-enforced to ensure downstream flow through culverts and road crossings. The final data is now available for download as part of the National Hydrography Dataset.

Contact Information for Client:
Jessica Coughlin, Operations Manager
Institute for the Application of Geospatial Technology (IAGT)
199 Franklin Street, Suite 300
Auburn, NY 13021
315-252-8669
jcoughlin@iagt.org

Project Name: New York City DEP High Resolution Land Cover Mapping
Period of Project: 2011-2013
Approximate Size of Project: ~$450K

Project Summary:
GroundPoint Technologies, in collaboration with the James W. Sewall Company and the University of Vermont completed delivery of high resolution Land Use and Land Cover data to the New York City Department of Environmental Protection. The Land Cover data includes an unprecedented mapping of the watersheds' impervious surfaces. Accuracy of over 94% for impervious surfaces was based on over a thousand check points. The project relied on eCognition software from Trimble to perform Object Based Image Analysis (OBIA) fusing LiDAR and high resolution aerial imagery. New York City is using the data to support improvements in their water quality modeling and land use protection programs.

Contact Information for Client:
Terry Spies, GIS Manager
NYCDEP Bureau of Water Supply
Watershed Protection and Planning, GIS Section
71 Smith Avenue
Kingston, New York 12401
845-340-7809
tspies@dep.nyc.gov

Pricing

VI.C.1. and VI.C.2. Digital Orthophotography and Digital Oblique Photography

County/Area	12" Cost			9" Cost		6"/9" (Ortho/Oblq) Cost		6" Cost		3" Cost	
	Area	Sq. Mile	Total	Sq. Mile	Total	Sq. Mile	Total	Sq. Mile	Total	Sq. Mile	Total
Kenosha	278	$ 132.00	$ 36,696.00	$ 132.00	$ 36,696.00	$ 192.00	$ 53,376.00	$ 296.00	$ 82,288.00	$ 526.00	$146,228.00
Milwaukee	242	$ 132.00	$ 31,944.00	$ 132.00	$ 31,944.00	$ 192.00	$ 46,464.00	$ 316.00	$ 76,472.00		
Ozaukee	234	$ 132.00	$ 30,888.00	$ 132.00	$ 30,888.00	$ 192.00	$ 44,928.00	$ 316.00	$ 73,944.00		
Racine	340	$ 132.00	$ 44,880.00	$ 132.00	$ 44,880.00	$ 172.00	$ 58,480.00	$ 296.00	$100,640.00		
Walworth	578	$ 132.00	$ 76,296.00	$ 132.00	$ 76,296.00	$ 172.00	$ 99,416.00	$ 296.00	$171,088.00		
Washington	436	$ 132.00	$ 57,552.00	$ 132.00	$ 57,552.00	$ 172.00	$ 74,992.00	$ 296.00	$129,056.00		
Waukesha	581	$ 132.00	$ 76,692.00	$ 132.00	$ 76,692.00	$ 172.00	$ 99,932.00	$ 296.00	$171,976.00		
Out-of-Region Area	278	$ 132.00	$ 36,696.00	$ 132.00	$ 36,696.00	$ 172.00	$ 47,816.00	$ 296.00	$ 82,288.00		
Total Area	2,967	$ 132.00	$391,644.00	$ 132.00	$391,644.00	$ 172.00	$510,324.00	$ 296.00	$878,232.00		

*This pricing represents the costs for the first image capture of Pictometry's Long Term Incentive pricing (15%) plus an additional 5% as a short-term promotional offer. SEWRPC can lock in subsequent incentives by signing a multi-year contract for two additonal image captures. This pricing is dependent upon the whole county area being captured at specified resolution.

** A SEWRPC AccuPlus imagery contract will include (at no additional charge): Area-wide mosaics and individual tiles, Electronic Field Study desktop software, 50 concurrent seats of Pictometry Connect for three years, one 1-Terabyte external hard drive, Pictometry's Disaster Recovery Program, Onsite and webinar training, Software maintenance, and Onsite technical and account support.

VI.C.3. LiDAR Data

County	1.0 Meter Posting, Stand-Alone Cost			1.0 Meter Posting, w/ Imagery Cost		0.7 Meter Posting, Stand-Alone Cost		0.7 Meter Posting, w/ Imagery Cost	
	Area	Sq. Mile	Total	Sq. Mile	Total	Sq. Mile	Total	Sq. Mile	Total
Kenosha	278	$ 213.00	$ 59,214.00	$ 138.45	$ 38,489.10	$ 350.00	$ 97,300.00	$ 227.50	$ 63,245.00
Milwaukee	242	$ 228.00	$ 55,176.00	$ 148.20	$ 35,864.40	$ 353.00	$ 85,426.00	$ 229.45	$ 55,526.90
Ozaukee	234	$ 231.50	$ 54,171.00	$ 150.48	$ 35,211.15	$ 356.00	$ 83,304.00	$ 231.40	$ 54,147.60
Racine	340	$ 195.00	$ 66,300.00	$ 126.75	$ 43,095.00	$ 316.00	$107,440.00	$ 205.40	$ 69,836.00
Walworth	578	$ 180.00	$104,040.00	$ 117.00	$ 67,626.00	$ 281.00	$162,418.00	$ 182.65	$105,571.70
Washington	436	$ 188.00	$ 81,968.00	$ 122.20	$ 53,279.20	$ 288.00	$125,568.00	$ 187.20	$ 81,619.20
Waukesha	581	$ 180.00	$104,580.00	$ 117.00	$ 67,977.00	$ 281.00	$163,261.00	$ 182.65	$106,119.65
Multiple Counties	1000+	$ 150.00		$ 90.00		$ 280.00		$ 180.00	

VI.C.4. Digital Terrain Model Files

County	Area	200-Scale DTM Cost	100-Scale DTM Cost
Kenosha	278	$ 25,020.00	$ 25,020.00
Milwaukee	242	$ 21,780.00	$ 21,780.00
Ozaukee	234	$ 21,060.00	$ 21,060.00
Racine	340	$ 30,600.00	$ 30,600.00
Walworth	578	$ 52,020.00	$ 52,020.00
Washington	436	$ 39,240.00	$ 39,240.00
Waukesha	581	$ 52,290.00	$ 52,290.00

VI.C.5. Contour Line Files*

County	Area	200-Scale Without Text Cost	200-Scale With Text Cost	100-Scale Without Text Cost	100-Scale With Text Cost
Kenosha	278	$ 4,170.00	$ 4,170.00	$ 5,560.00	$ 5,560.00
Milwaukee	242	$ 3,630.00	$ 3,630.00	$ 4,840.00	$ 4,840.00
Ozaukee	234	$ 3,510.00	$ 3,510.00	$ 4,680.00	$ 4,680.00
Racine	340	$ 5,100.00	$ 5,100.00	$ 6,800.00	$ 6,800.00
Walworth	578	$ 8,670.00	$ 8,670.00	$ 11,560.00	$ 11,560.00
Washington	436	$ 6,540.00	$ 6,540.00	$ 8,720.00	$ 8,720.00
Waukesha	581	$ 8,715.00	$ 8,715.00	$ 11,620.00	$ 11,620.00
*Proposal is for contours delivered in database format, so text is included as an attribute and displays based on the labeling engine.					
Countour Line pricing requires DTM purchase.					

VI.C.6. Other Products

County		Interpretive Mapping Datasets		Transportation Breaklines		Connect 50 Cost
	Area	Sq. Mile	Total	Sq. Mile	Total	
Kenosha	278	$ 20.00	$ 5,560.00	$ 135.00	$ 37,530.00	Included*
Milwaukee	242	$ 20.00	$ 4,840.00	$ 135.00	$ 32,670.00	Included*
Ozaukee	234	$ 20.00	$ 4,680.00	$ 135.00	$ 31,590.00	Included*
Racine	340	$ 20.00	$ 6,800.00	$ 135.00	$ 45,900.00	Included*
Walworth	578	$ 20.00	$ 11,560.00	$ 135.00	$ 78,030.00	Included*
Washington	436	$ 20.00	$ 8,720.00	$ 135.00	$ 58,860.00	Included*
Waukesha	581	$ 20.00	$ 11,620.00	$ 135.00	$ 78,435.00	Included*
*$2,000 annual fee waived for three years						

County	Area	Additional LiDAR Classification - Includes Buildings, Bridgges, Vegetation, etc per proposal			
		1.0 Meter Posting, Stand-Alone Cost		0.7 Meter Posting, Stand-Alone Cost	
		Sq. Mile	Total	Sq. Mile	Total
Kenosha	278	$ 27.50	$ 7,645.00	$ 35.00	$ 9,730.00
Milwaukee	242	$ 27.50	$ 6,655.00	$ 35.00	$ 8,470.00
Ozaukee	234	$ 27.50	$ 6,435.00	$ 35.00	$ 8,190.00
Racine	340	$ 27.50	$ 9,350.00	$ 35.00	$ 11,900.00
Walworth	578	$ 27.50	$ 15,895.00	$ 35.00	$ 20,230.00
Washington	436	$ 27.50	$ 11,990.00	$ 35.00	$ 15,260.00
Waukesha	581	$ 27.50	$ 15,977.50	$ 35.00	$ 20,335.00

Pricing noted above is guaranteed until June 25, 2014, and is to be considered Proprietary and Confidential Information.

Appendices

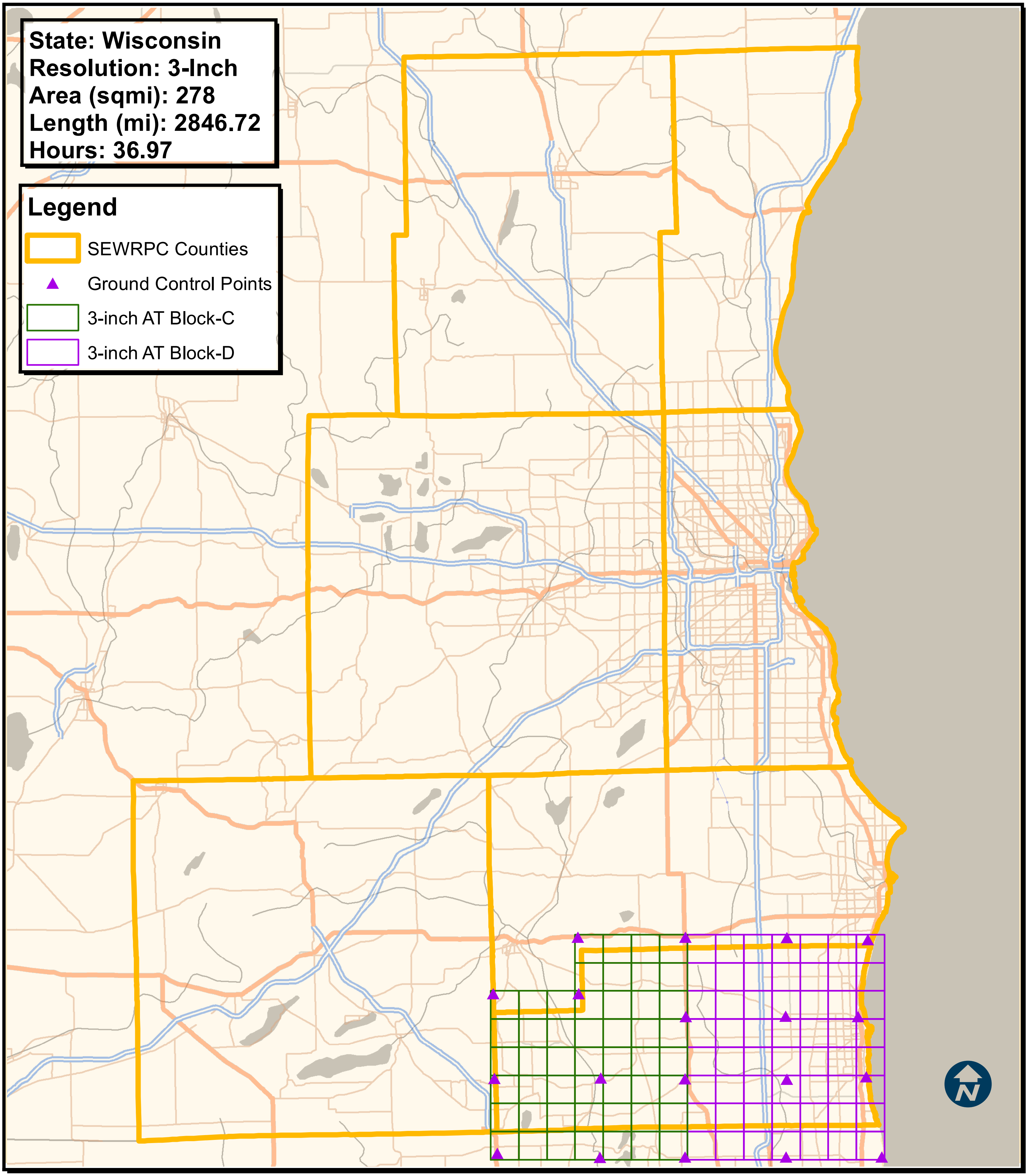
Pictometry has included the following as appendices to this document for reference:

Appendix A: Project Maps
Maps showing sample flight plans and estimated flight statistics

Appendix B: Relative Measurement Accuracies within Pictometry's Individual Orthogonal and Oblique Frame Imagery©

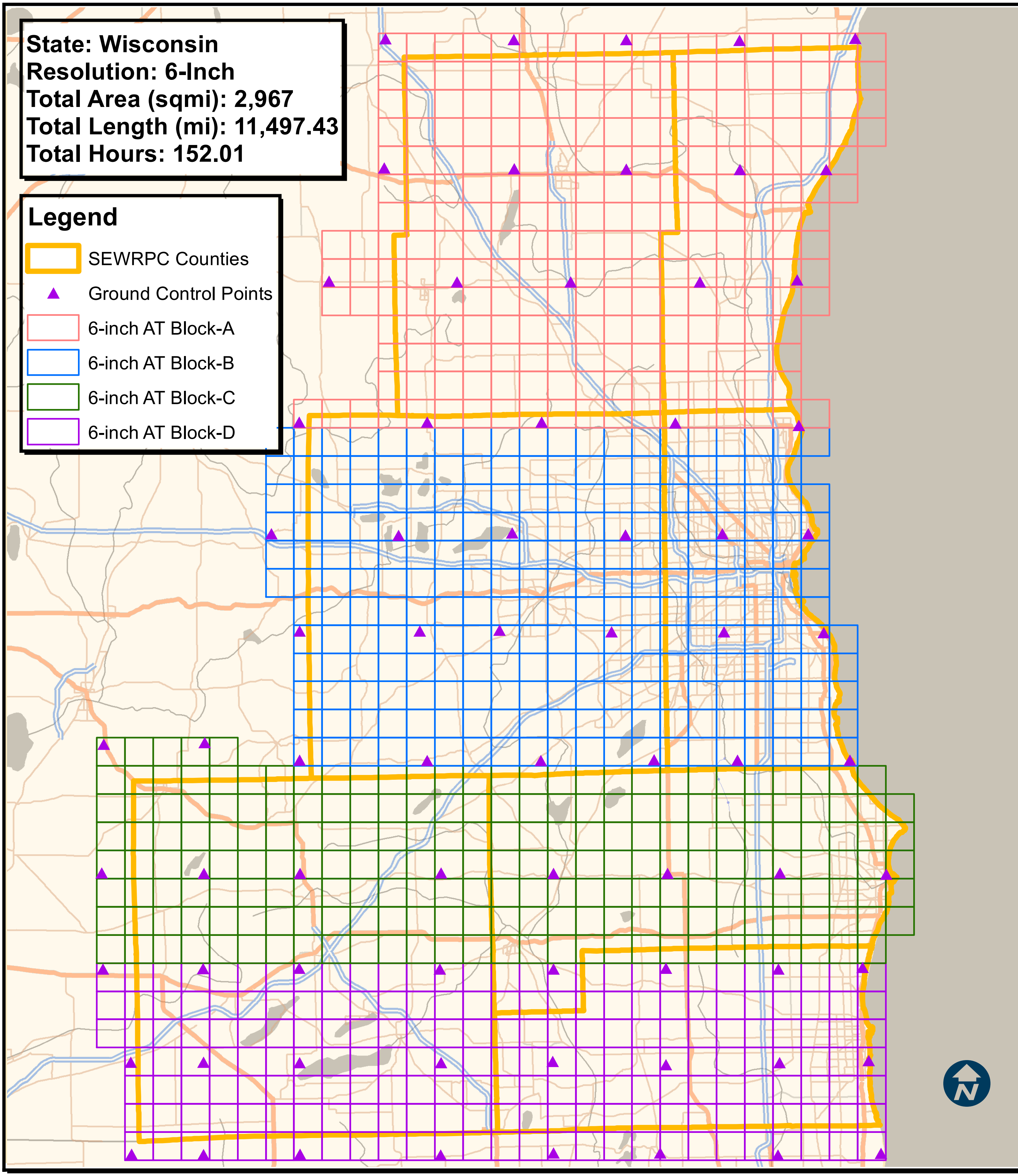
SE Wisconsin RPC
Aerial Triangulation Blocks
3-Inch Resolution

PICTOMETRY
INTELLIGENT IMAGES



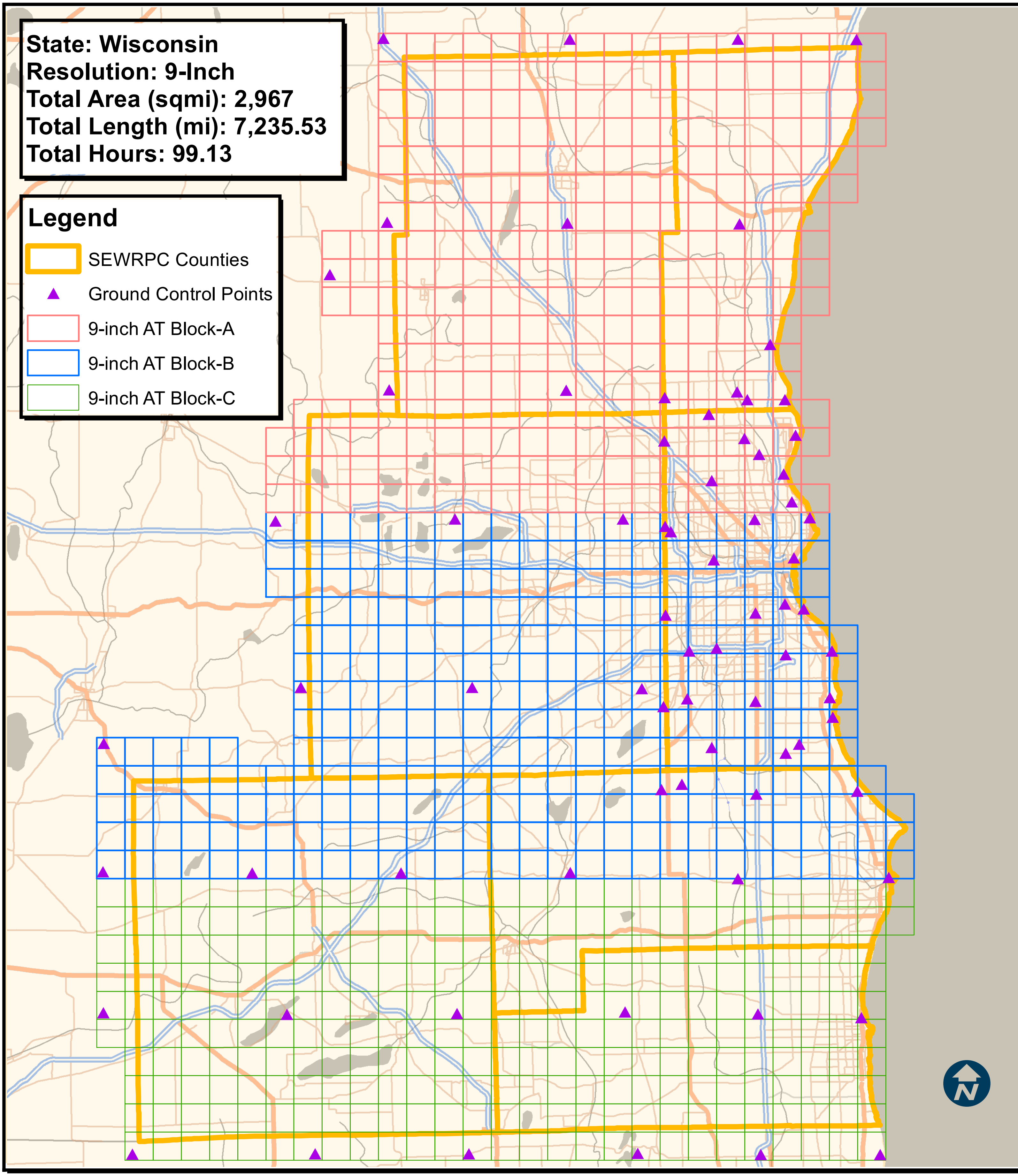
SE Wisconsin RPC
Aerial Triangulation Blocks
6-Inch Resolution

PICTOMETRY
INTELLIGENT IMAGES



SE Wisconsin RPC Aerial Triangulation Blocks 9-Inch Resolution

PICTOMETRY
INTELLIGENT IMAGES

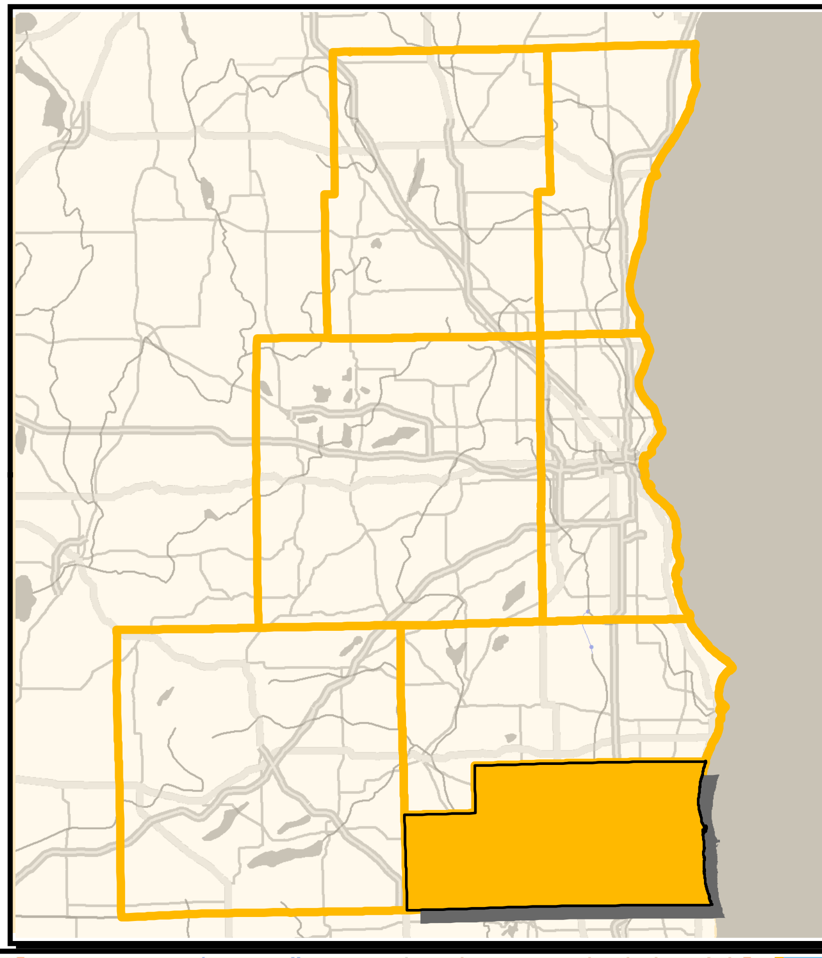


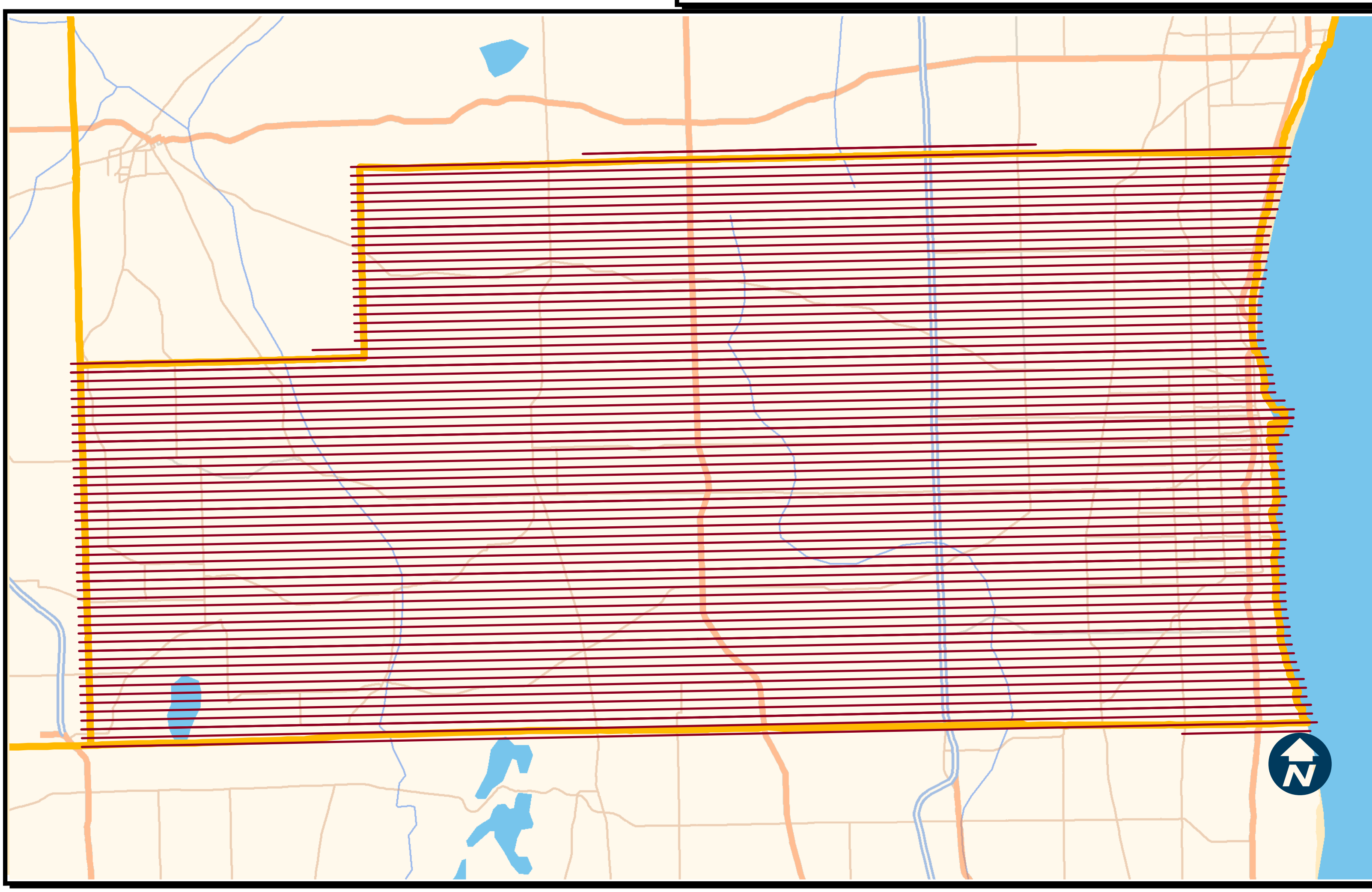
SE Wisconsin RPC
Kenosha County
Flight Plan
3-Inch Resolution

State: Wisconsin
County: Kenosha
Resolution: 3-Inch
Area (sqmi): 278
Length (mi): 2846.72
Hours: 36.97

Legend

Kenosha 3-inch Flight Plan
County



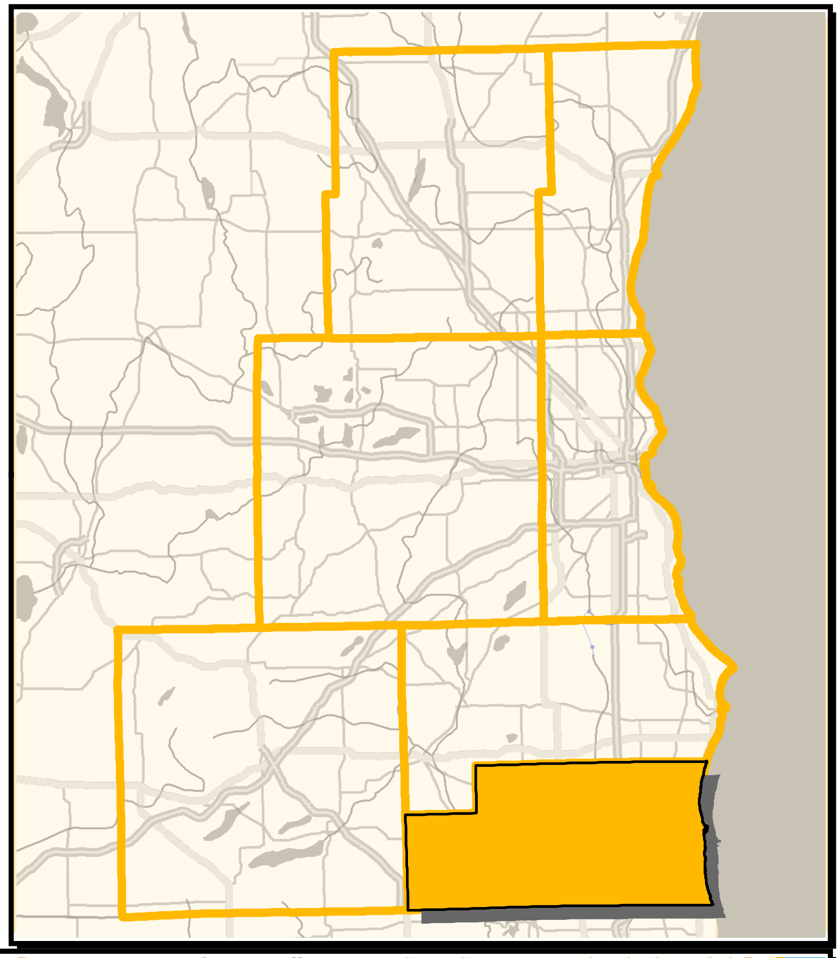


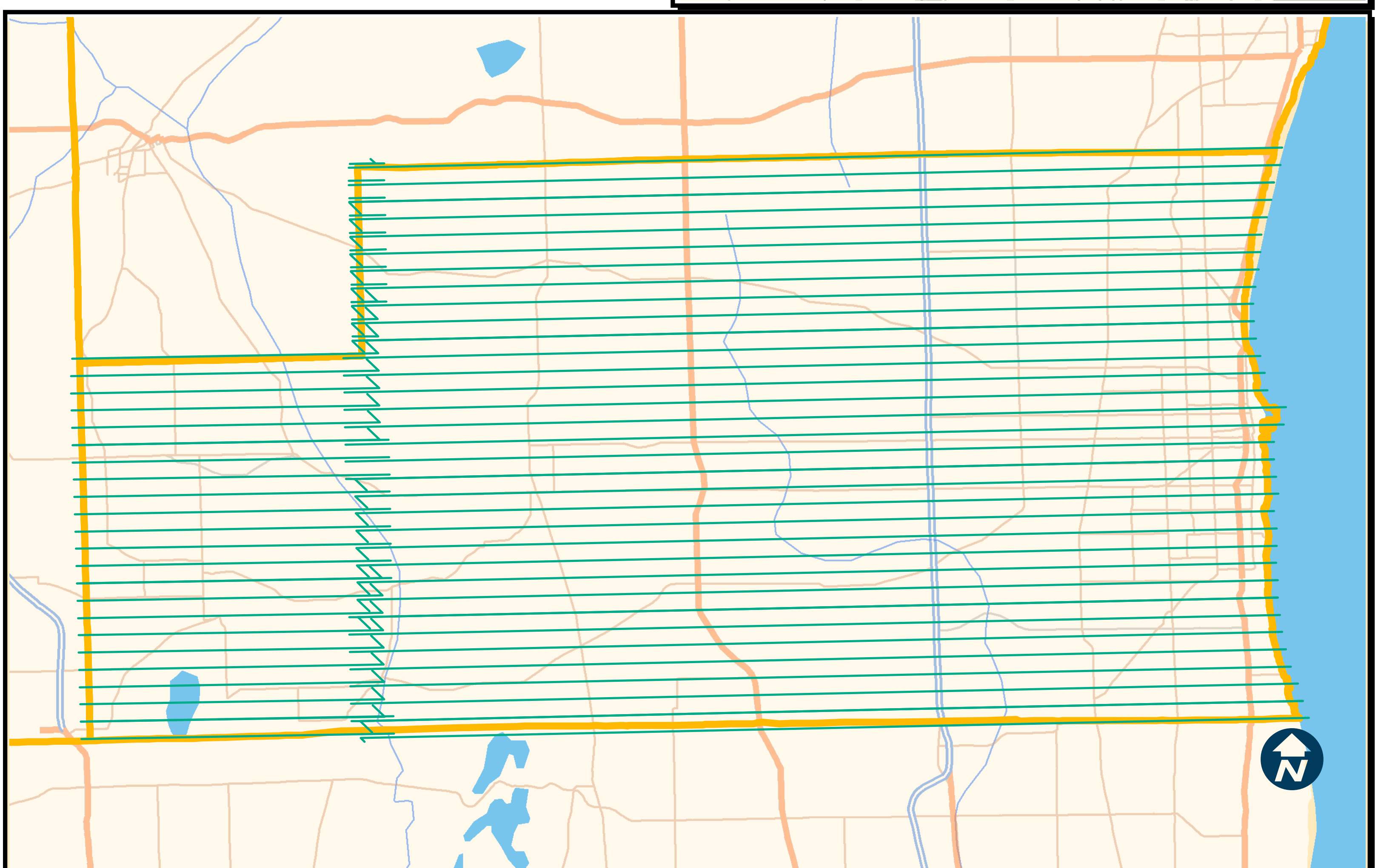
SE Wisconsin RPC
Kenosha County
Flight Plan
6-Inch Resolution

State: Wisconsin
County: Kenosha
Resolution: 6-Inch
Area (sqmi): 278
Length (mi): 1078.64
Hours: 14.18

Legend

Kenosha 6-inch Flight Plan
County



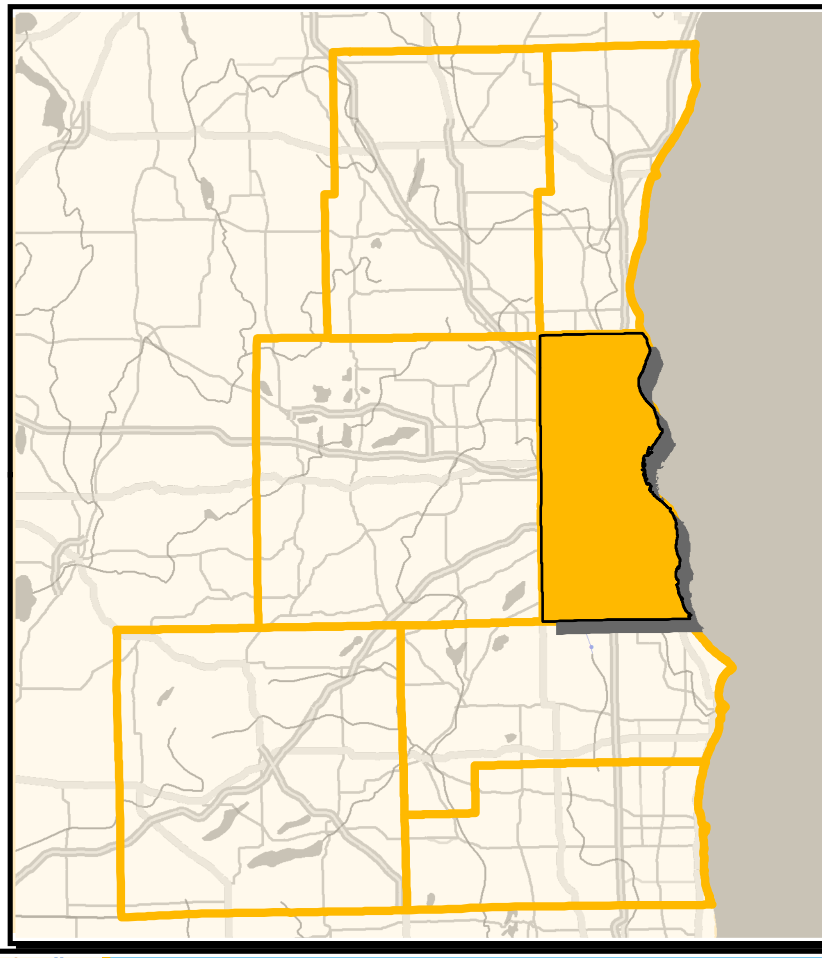


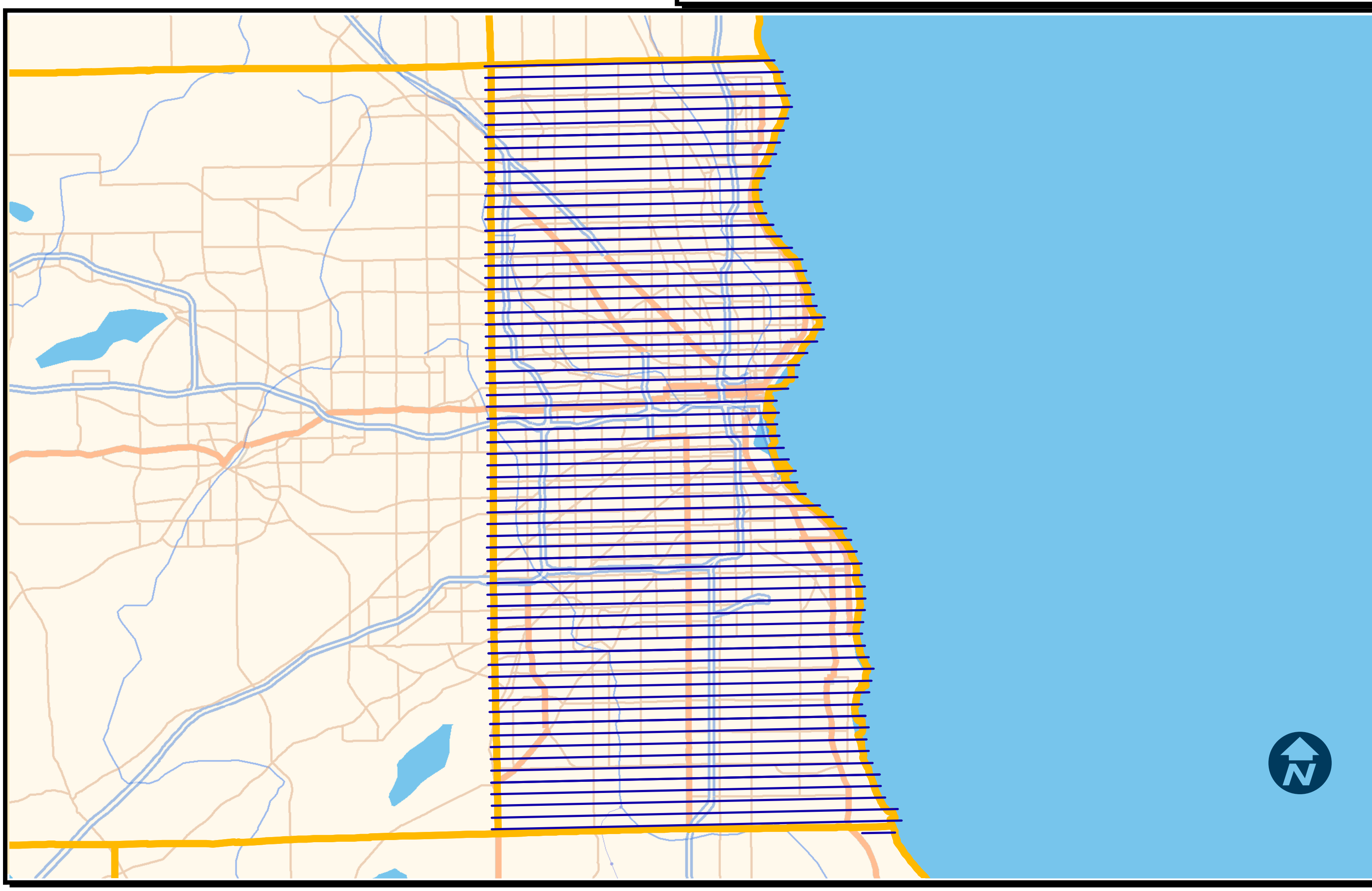
SE Wisconsin RPC
Milwaukee County
Flight Plan
6-Inch Resolution

State: Wisconsin
County: Milwaukee
Resolution: 6-Inch
Area (sqmi): 242
Length (mi): 938.96
Hours: 12.34

Legend

- Milwaukee 6-inch Flight Plan
- County





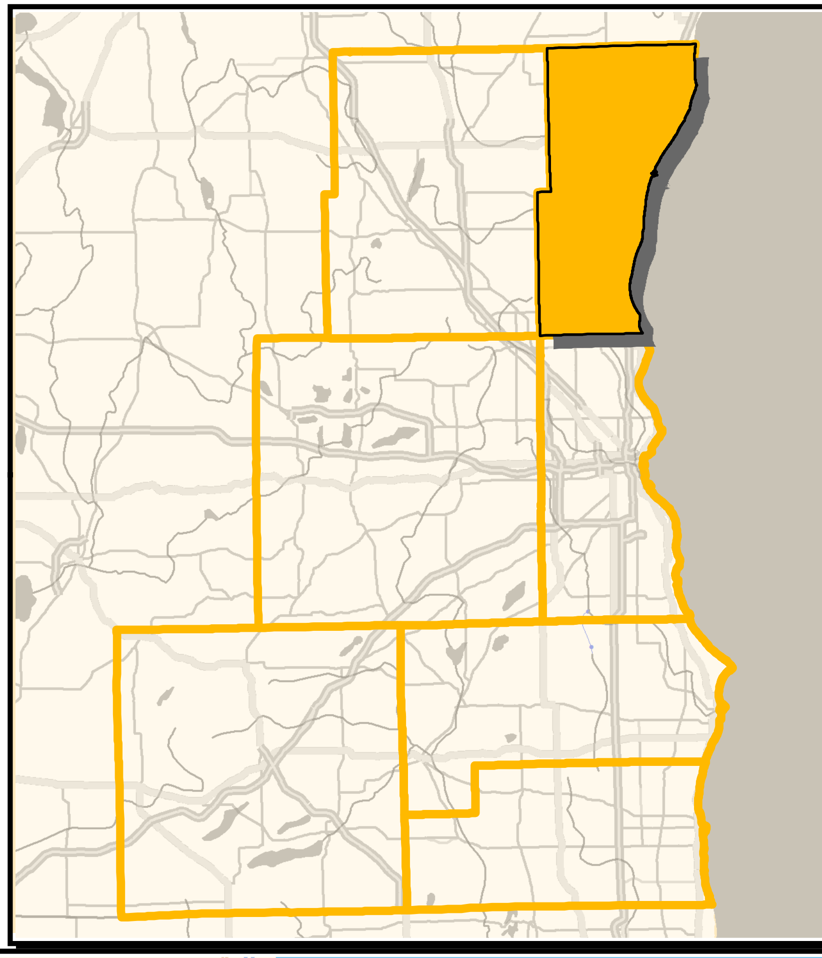
SE Wisconsin RPC
Ozaukee County
Flight Plan
6-Inch Resolution

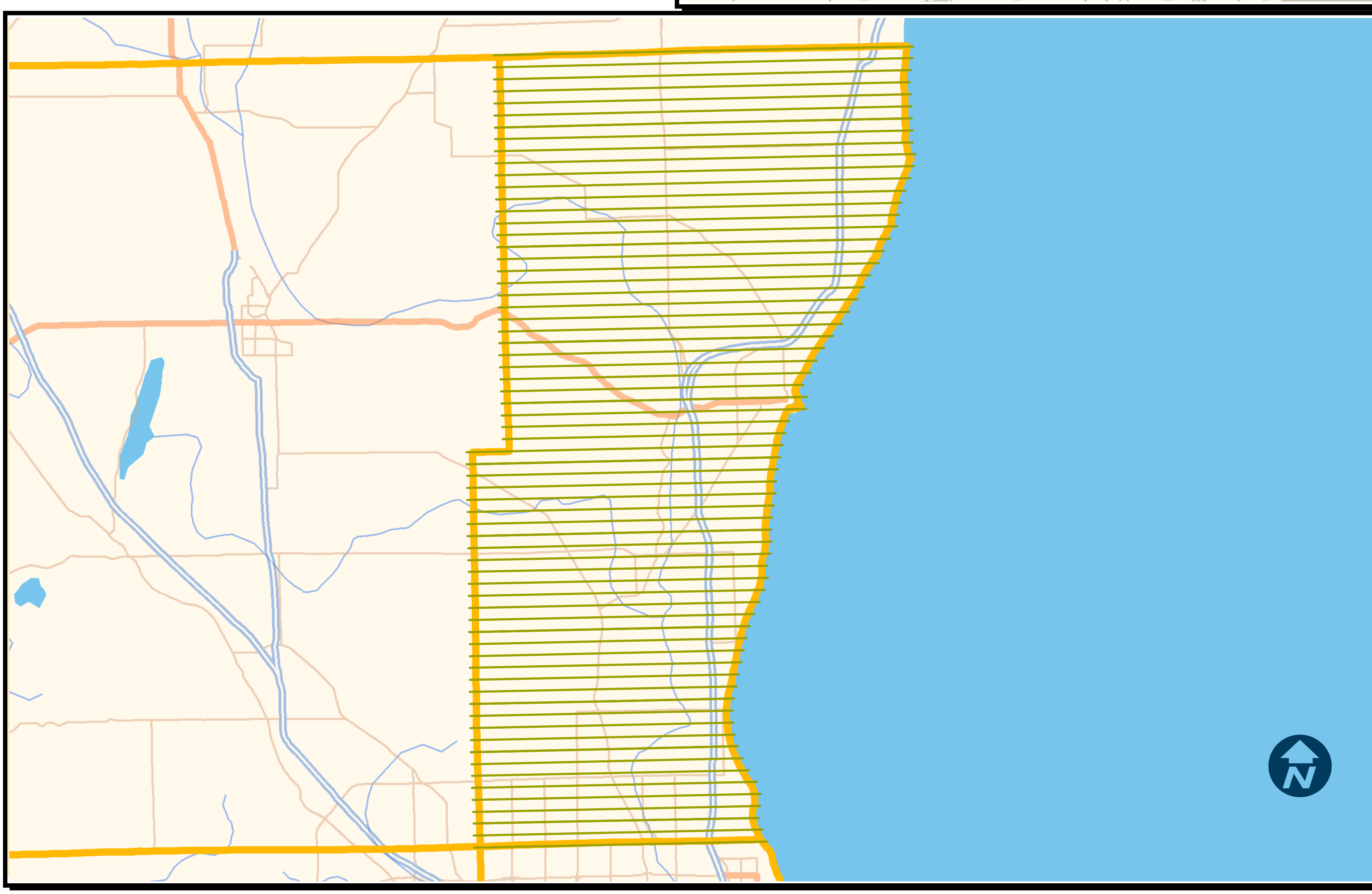
State: Wisconsin
County: Ozaukee
Resolution: 6-Inch
Area (sqmi): 234
Length (mi): 907.92
Hours: 11.93

Legend

Ozaukee 6-inch Flight Plan

County





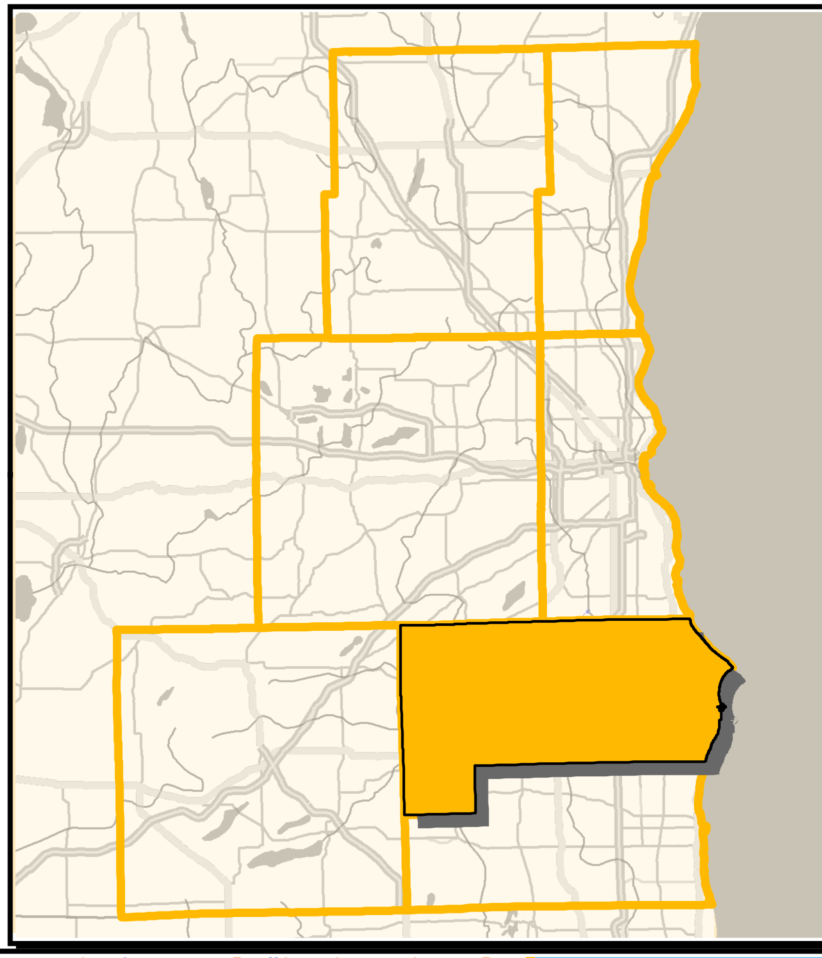
PICTOMETRY
INTELLIGENT IMAGES

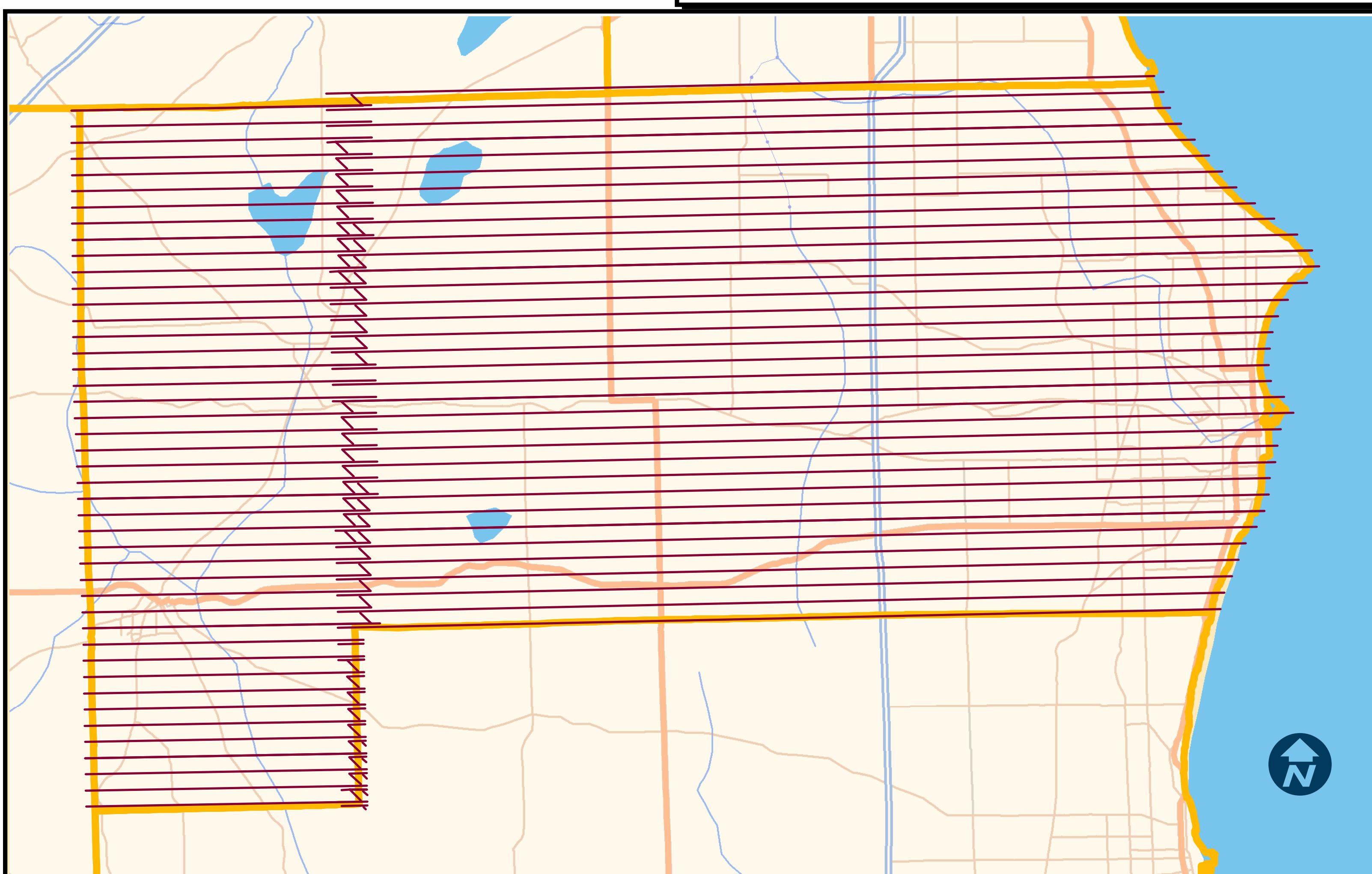
SE Wisconsin RPC
Racine County
Flight Plan
6-Inch Resolution

State: Wisconsin
County: Racine
Resolution: 6-Inch
Area (sqmi): 340
Length (mi): 1319.20
Hours: 17.34

Legend

Racine 6-inch Flight Plan
County





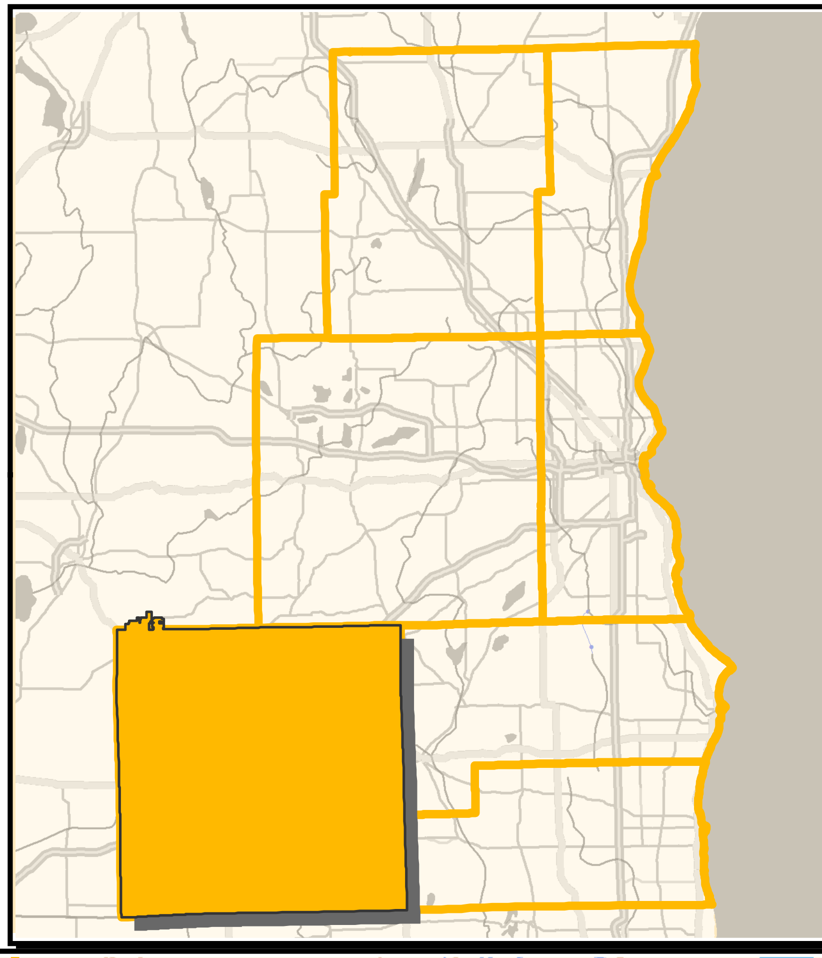
PICTOMETRY
INTELLIGENT IMAGES

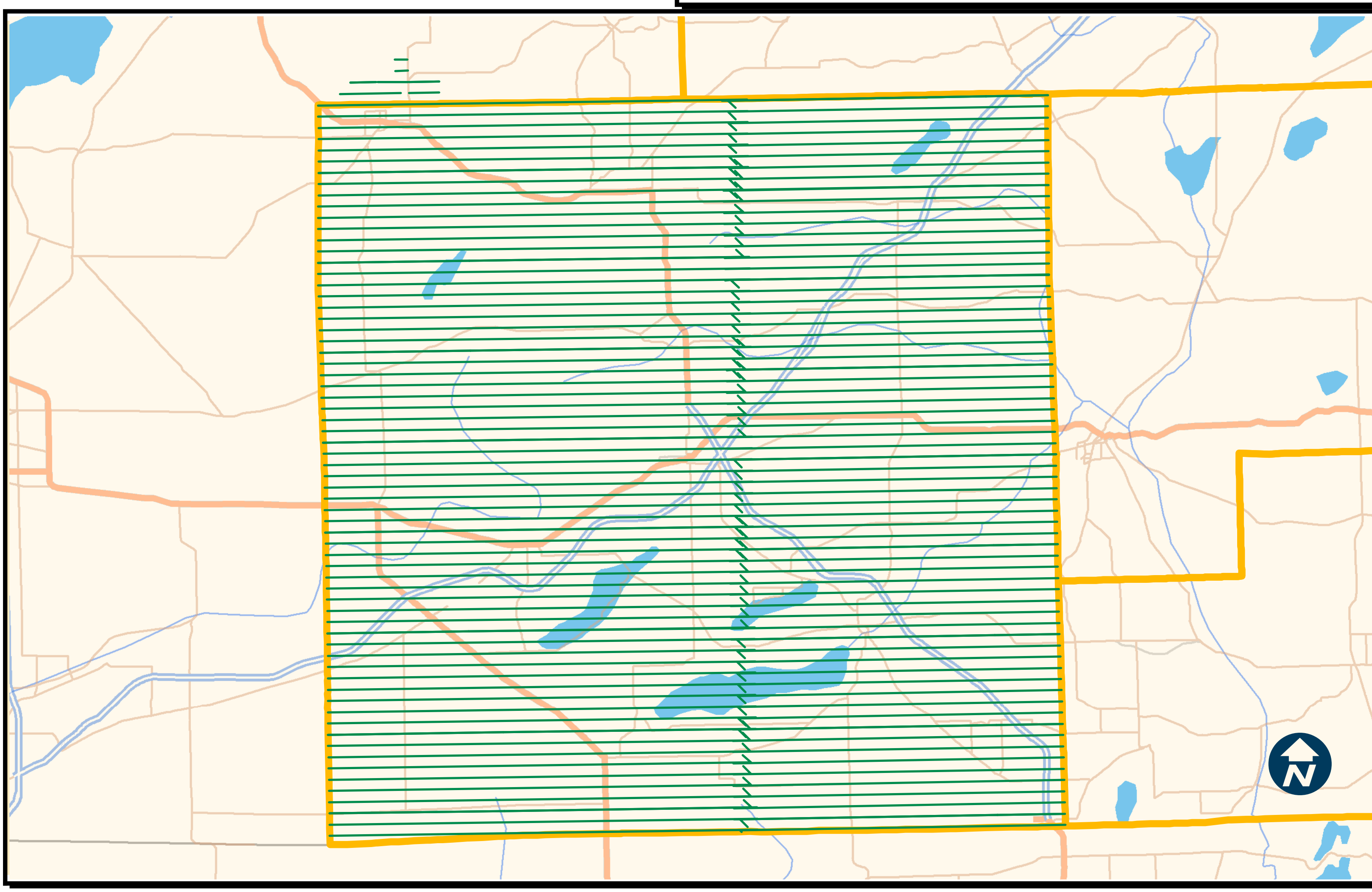
SE Wisconsin RPC
Walworth County
Flight Plan
6-Inch Resolution

State: Wisconsin
County: Walworth
Resolution: 6-Inch
Area (sqmi): 578
Length (mi): 2242.64
Hours: 29.478

Legend

- Walworth 6-inch Flight Plan
- County





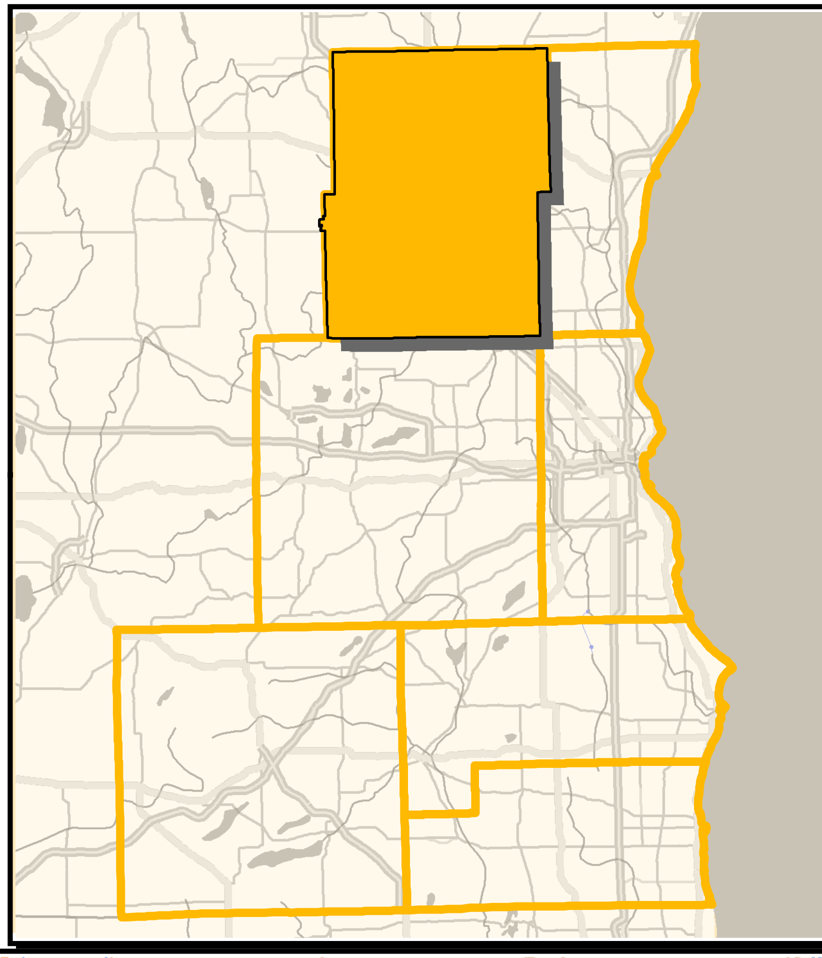
PICTOMETRY
INTELLIGENT IMAGES

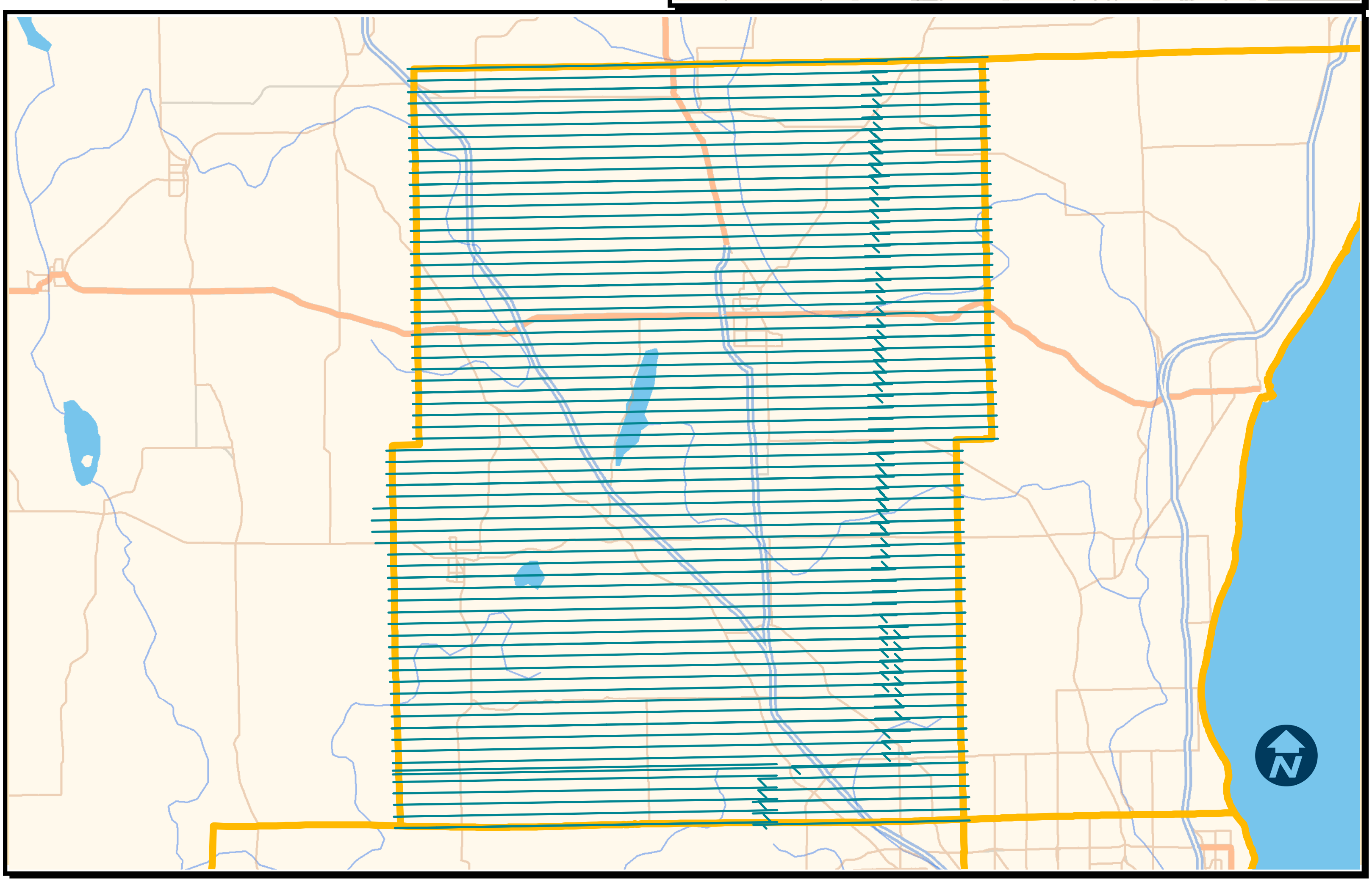
SE Wisconsin RPC Washington County Flight Plan 6-Inch Resolution

State: Wisconsin
County: Washington
Resolution: 6-Inch
Area (sqmi): 436
Length (mi): 1691.68
Hours: 22.236

Legend

Washington 6-inch Flight Plan
County



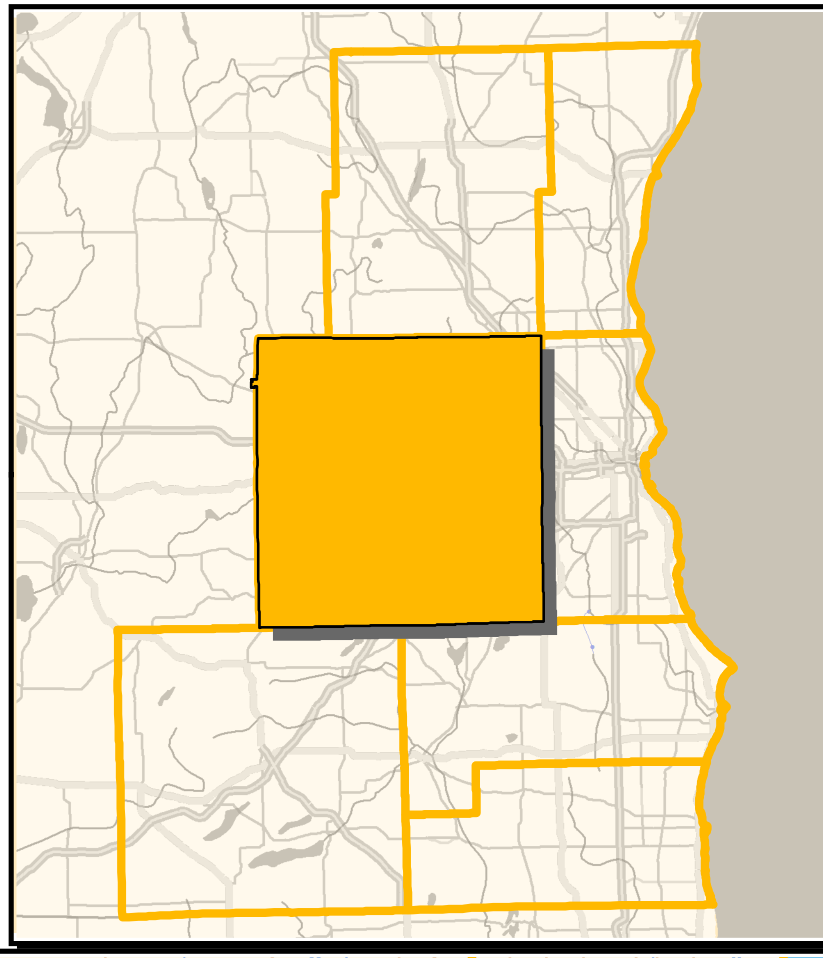


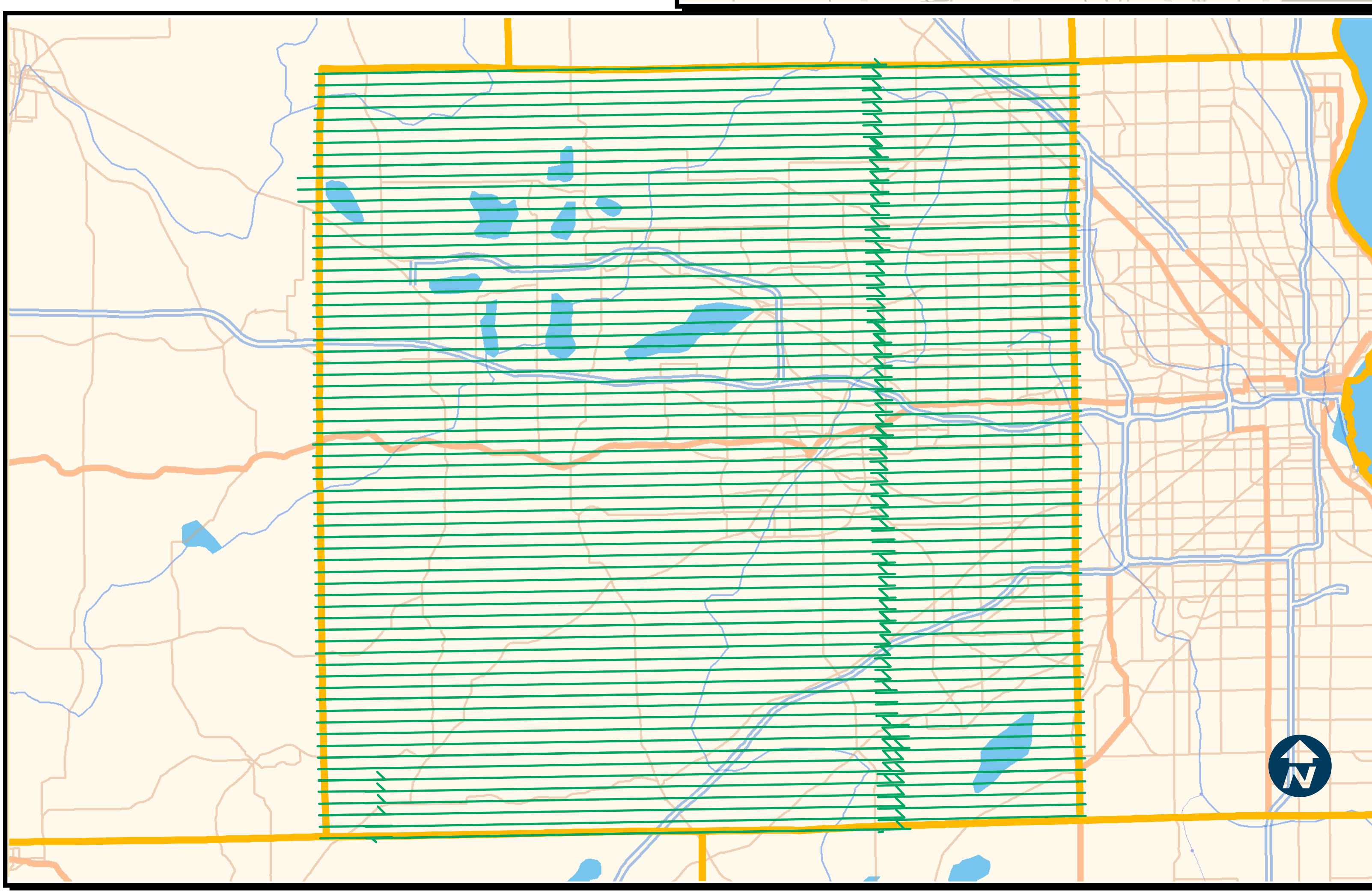
SE Wisconsin RPC Waukesha County Flight Plan 6-Inch Resolution

State: Wisconsin
County: Waukesha
Resolution: 6-Inch
Area (sqmi): 581
Length (mi): 2254.28
Hours: 29.631

Legend

- Waukesha 6-inch Flight Plan
- County



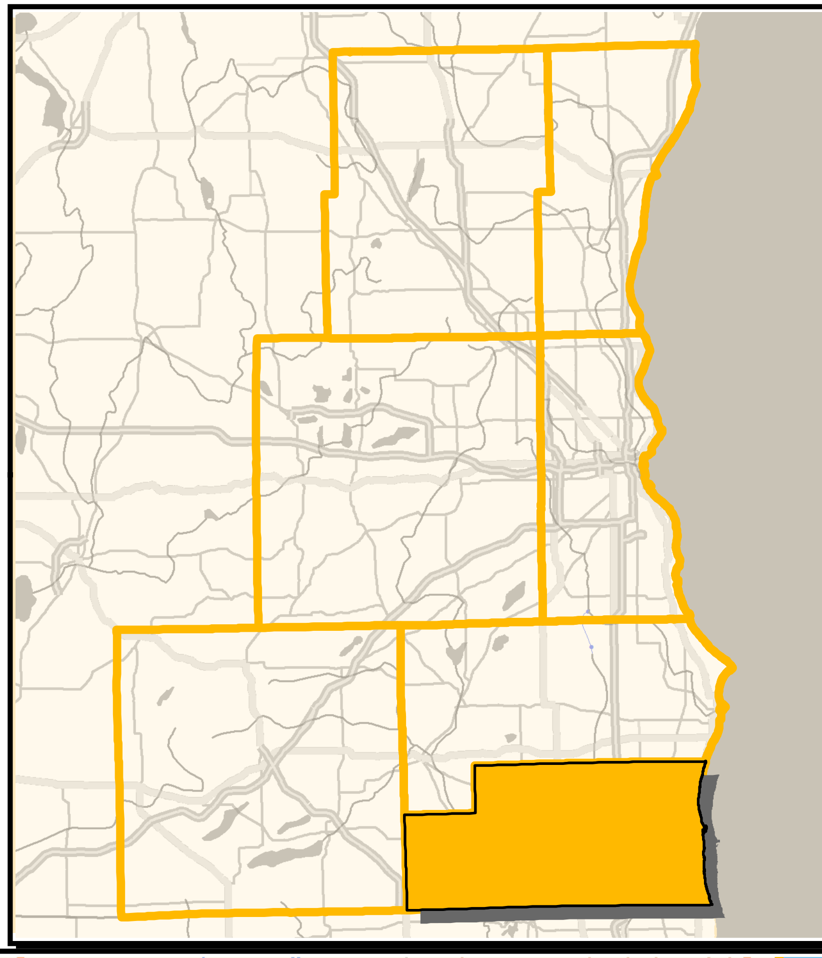


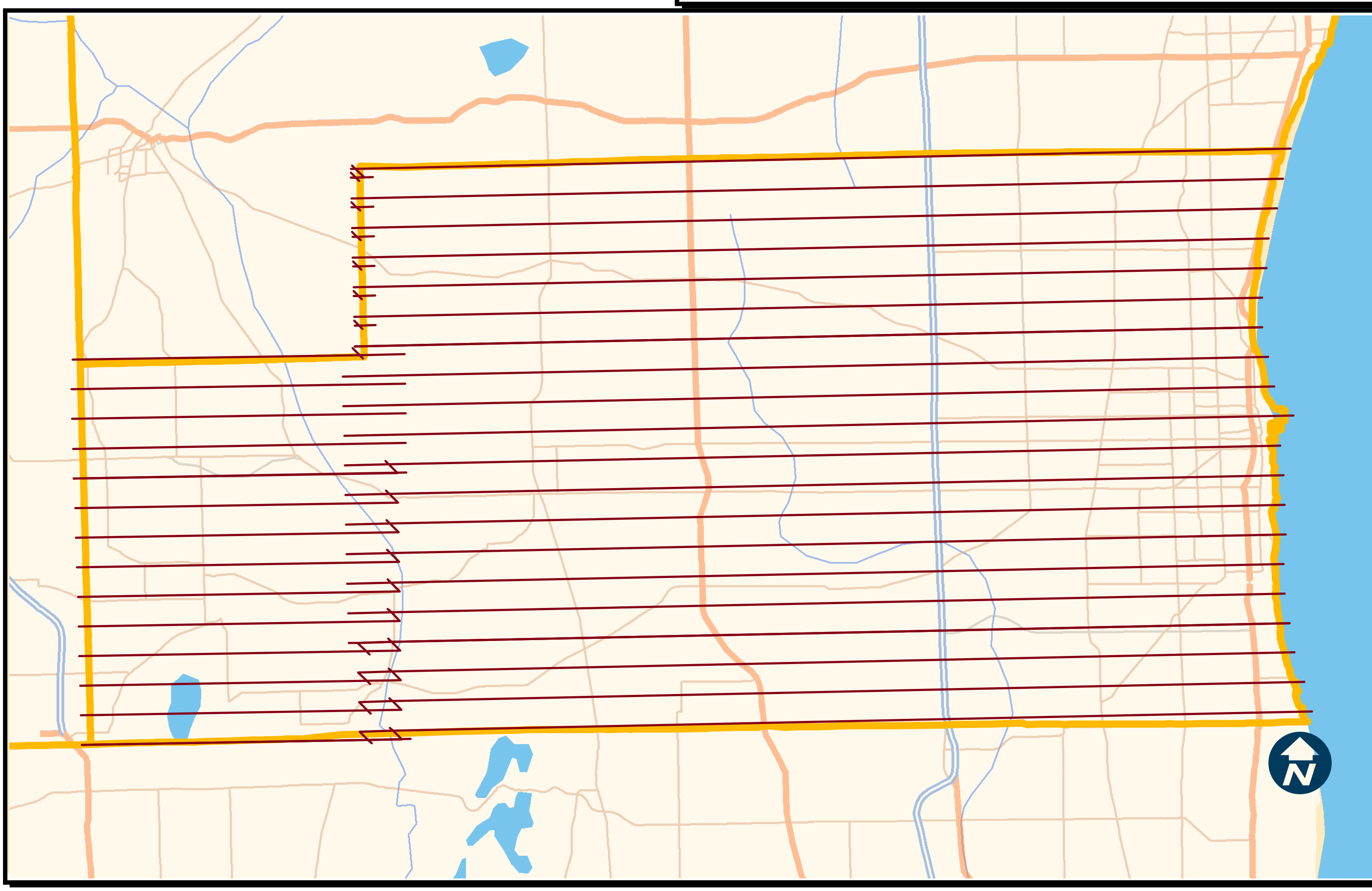
SE Wisconsin RPC
Kenosha County
Flight Plan
9-Inch Resolution

State: Wisconsin
County: Kenosha
Resolution: 9-Inch
Area (sqmi): 278
Length (mi): 678.32
Hours: 9.17

Legend

Kenosha 9-inch Flight Plan
County

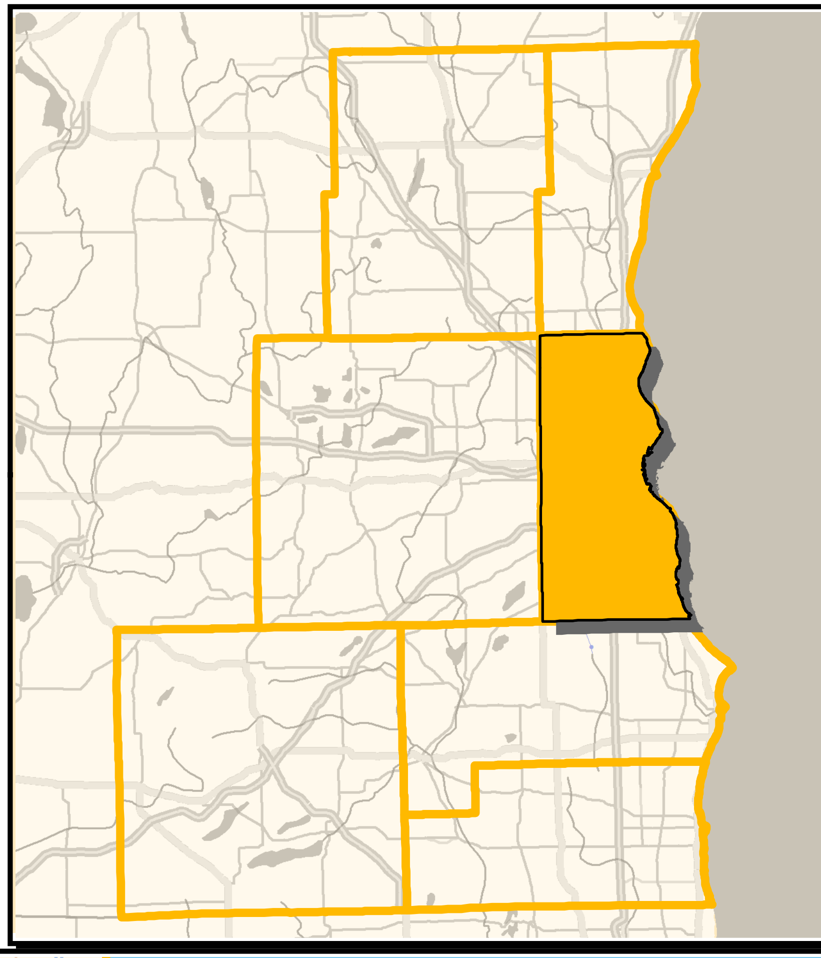




PICTOMETRY
INTELLIGENT IMAGES

SE Wisconsin RPC
Milwaukee County
Flight Plan
9-Inch Resolution

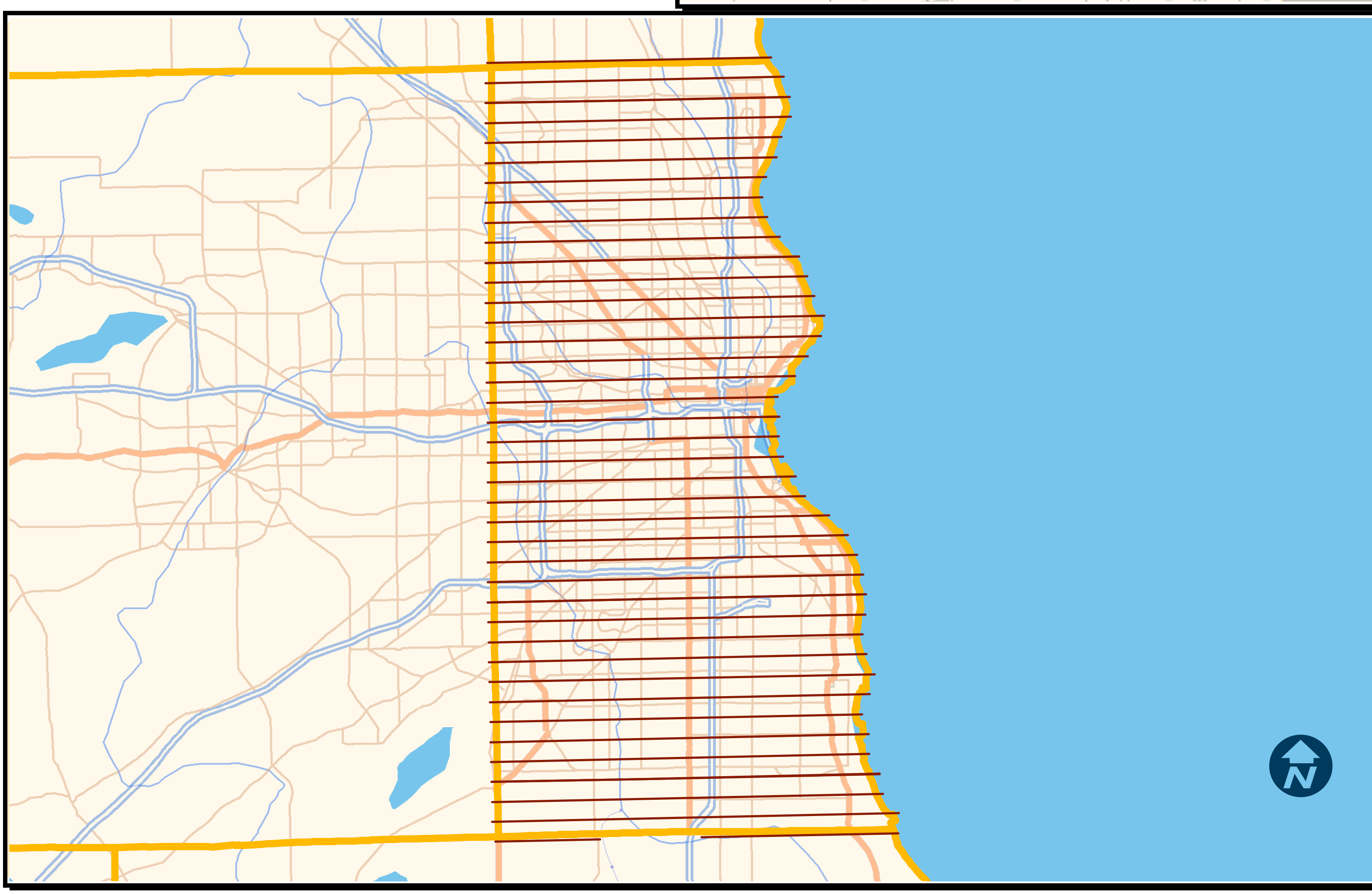
State: Wisconsin
County: Milwaukee
Resolution: 9-Inch
Area (sqmi): 242
Length (mi): 590.48
Hours: 7.99



Legend

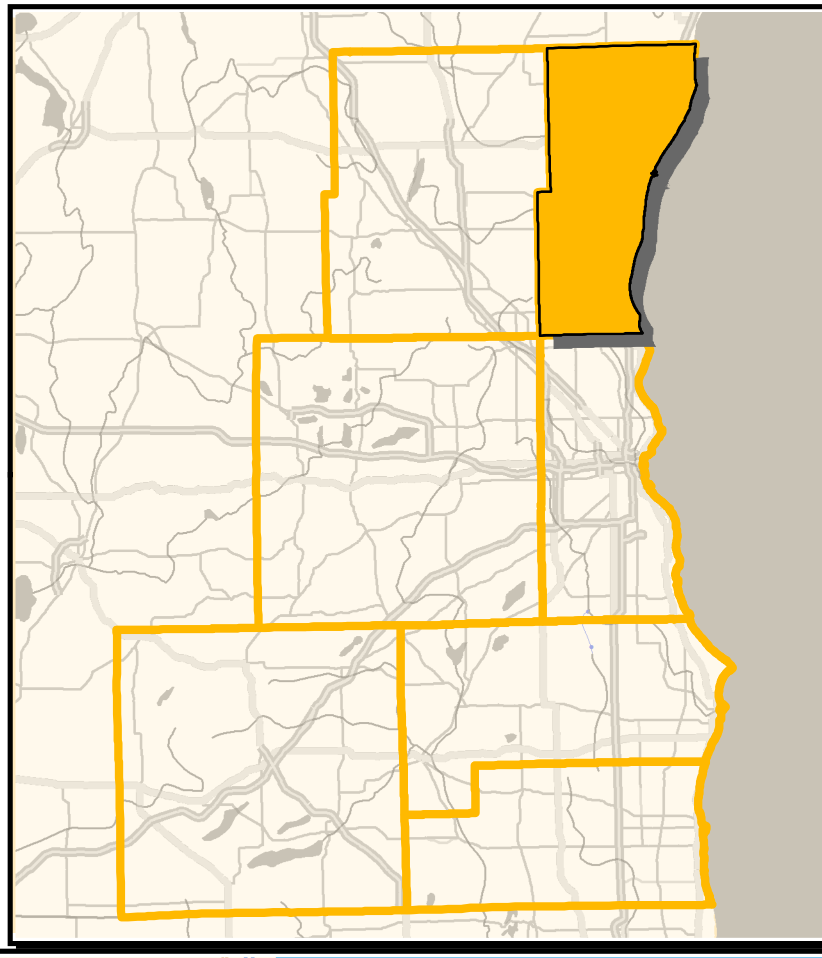
Milwaukee 9-inch Flight Plan

County



SE Wisconsin RPC
Ozaukee County
Flight Plan
9-Inch Resolution

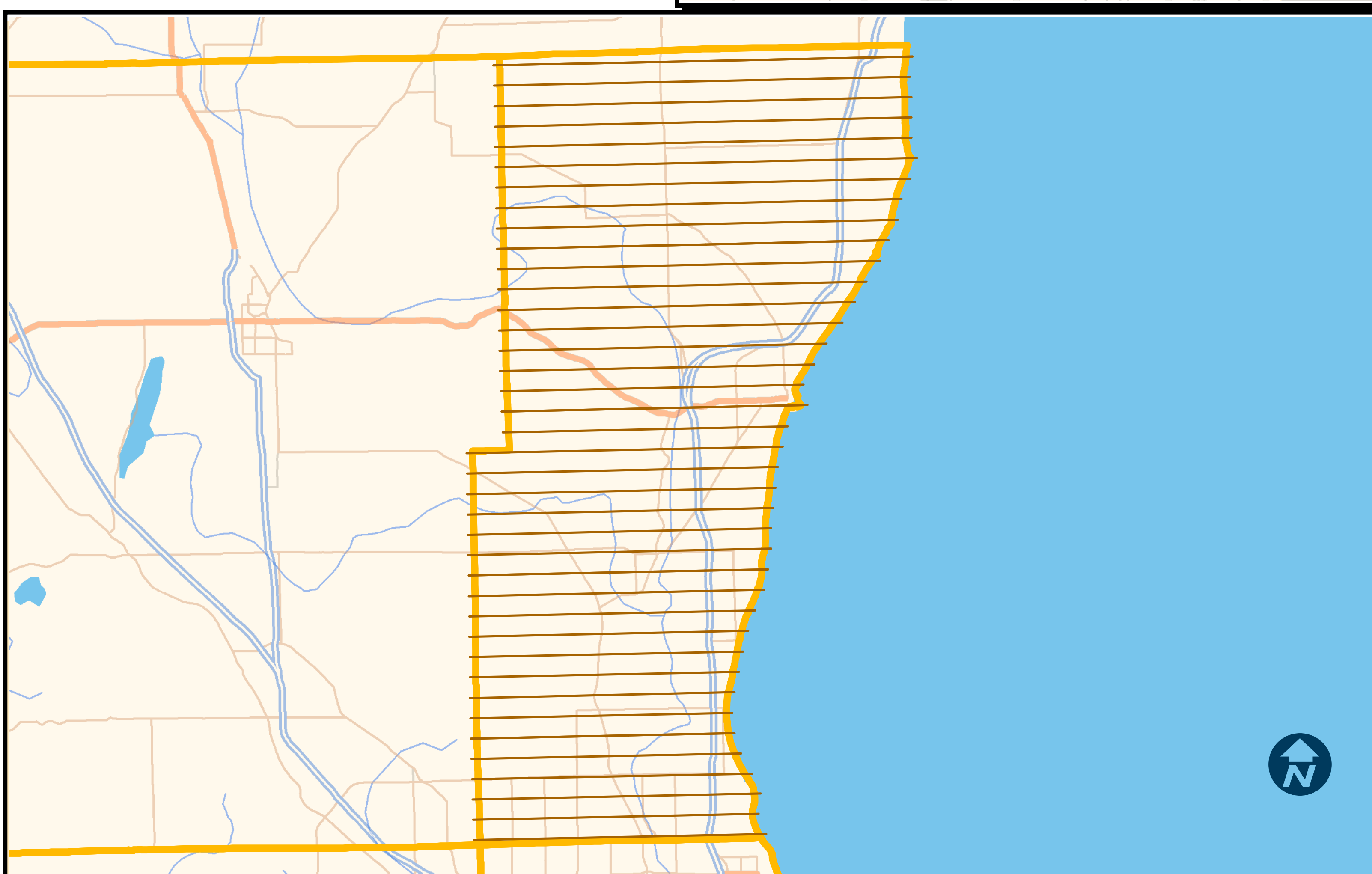
State: Wisconsin
County: Ozaukee
Resolution: 9-Inch
Area (sqmi): 234
Length (mi): 570.96
Hours: 7.72



Legend

Ozaukee 9-inch Flight Plan

County



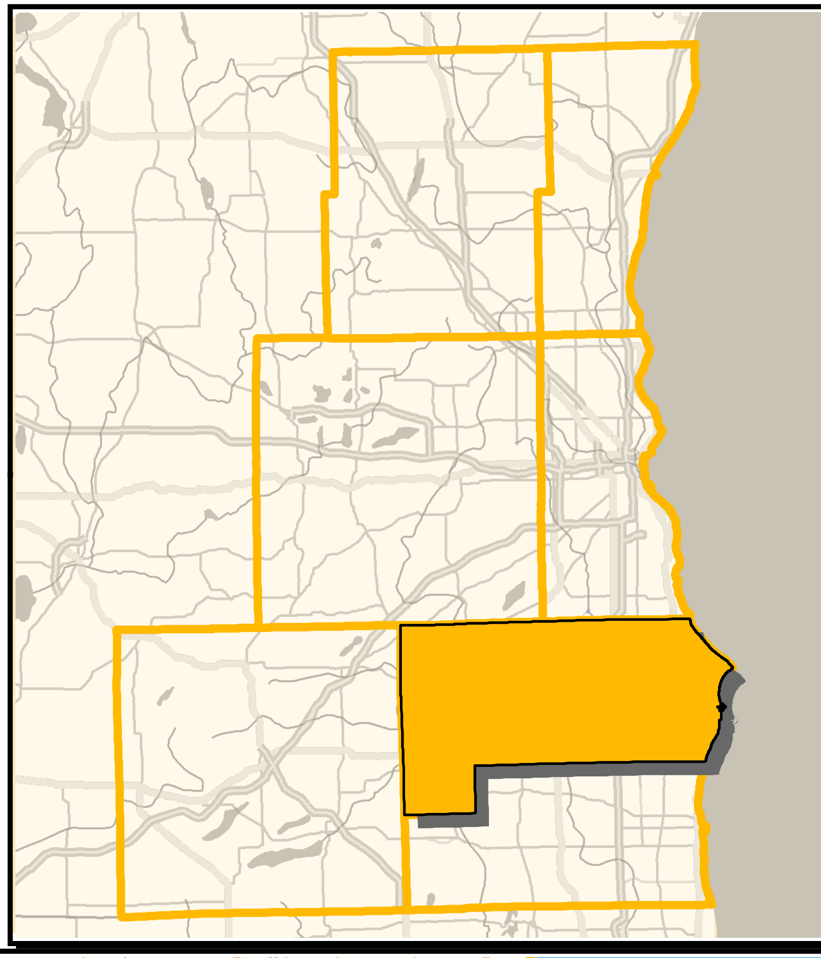
PICTOMETRY
INTELLIGENT IMAGES

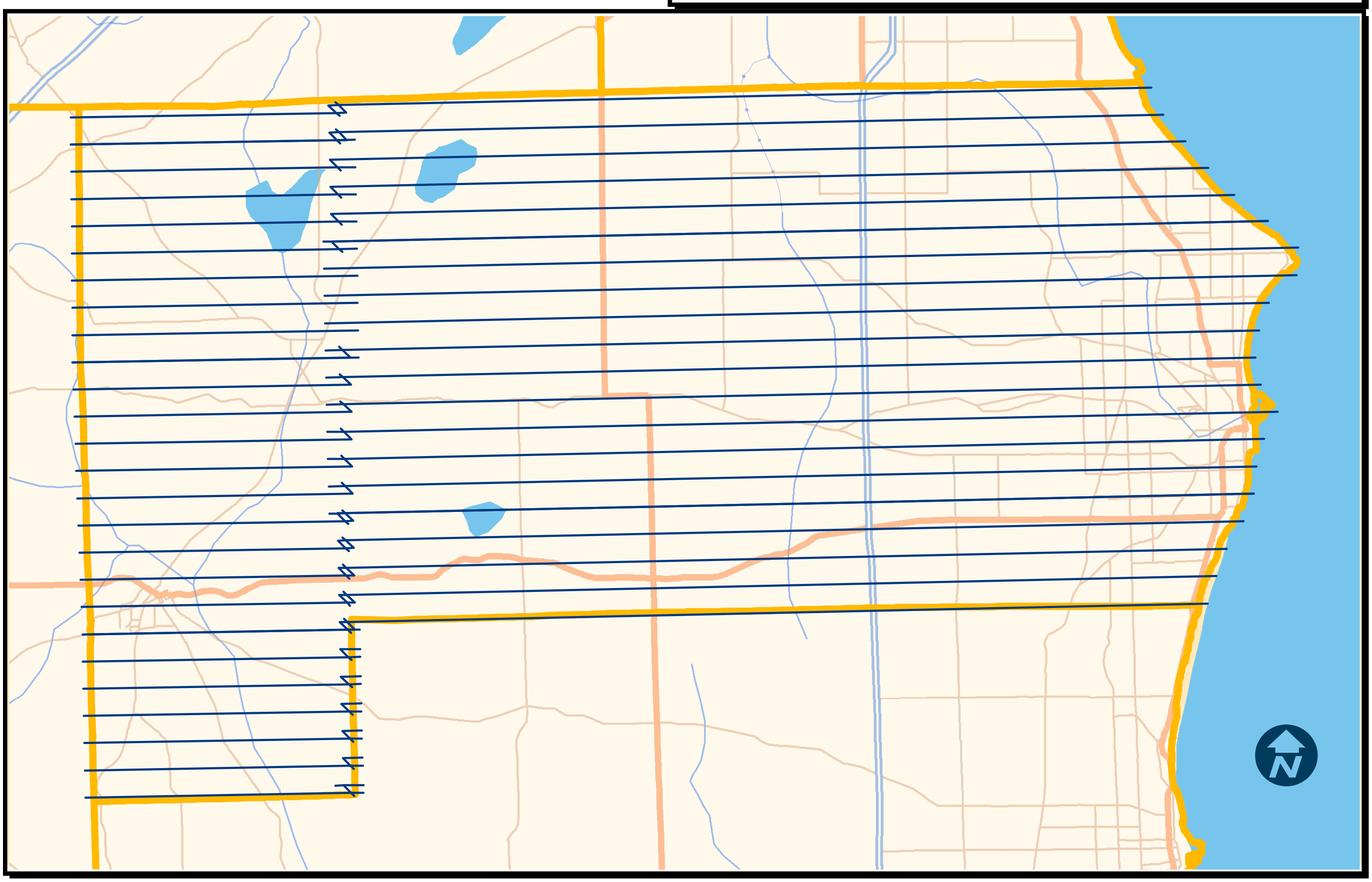
SE Wisconsin RPC
Racine County
Flight Plan
9-Inch Resolution

State: Wisconsin
County: Racine
Resolution: 9-Inch
Area (sqmi): 340
Length (mi): 829.60
Hours: 11.22

Legend

Racine 9-inch Flight Plan
County



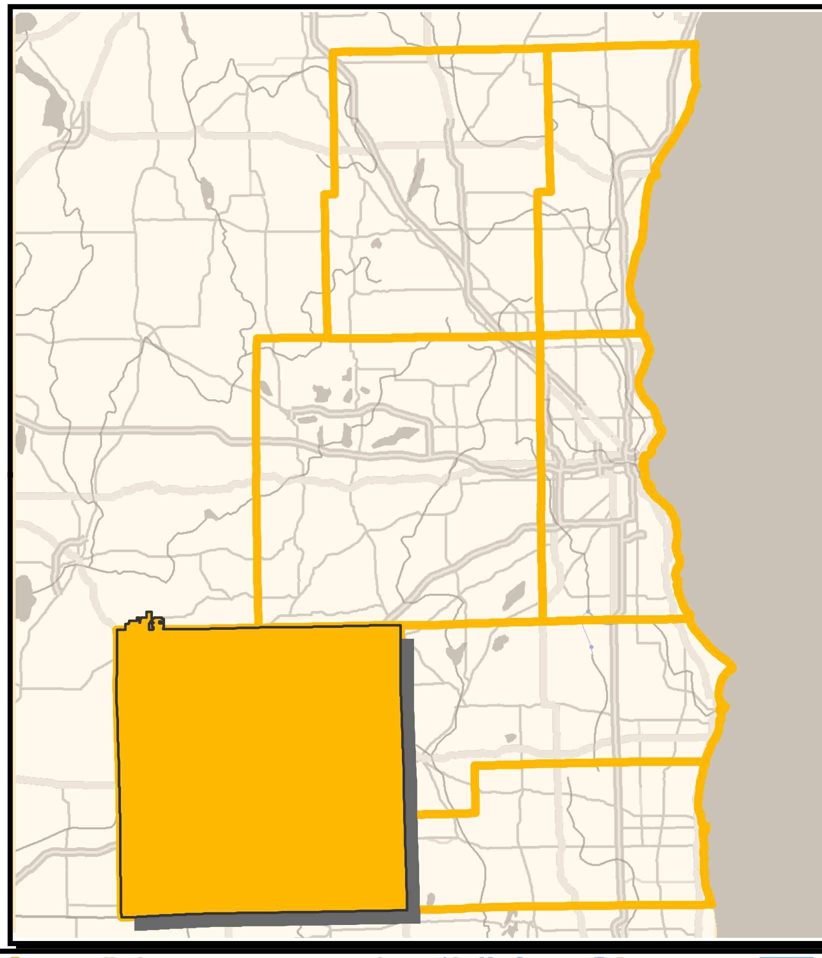


SE Wisconsin RPC Walworth County Flight Plan 9-Inch Resolution

State: Wisconsin
County: Walworth
Resolution: 9-Inch
Area (sqmi): 578
Length (mi): 1410.32
Hours: 19.07

Legend

- Walworth 9-inch Flight Plan
- County

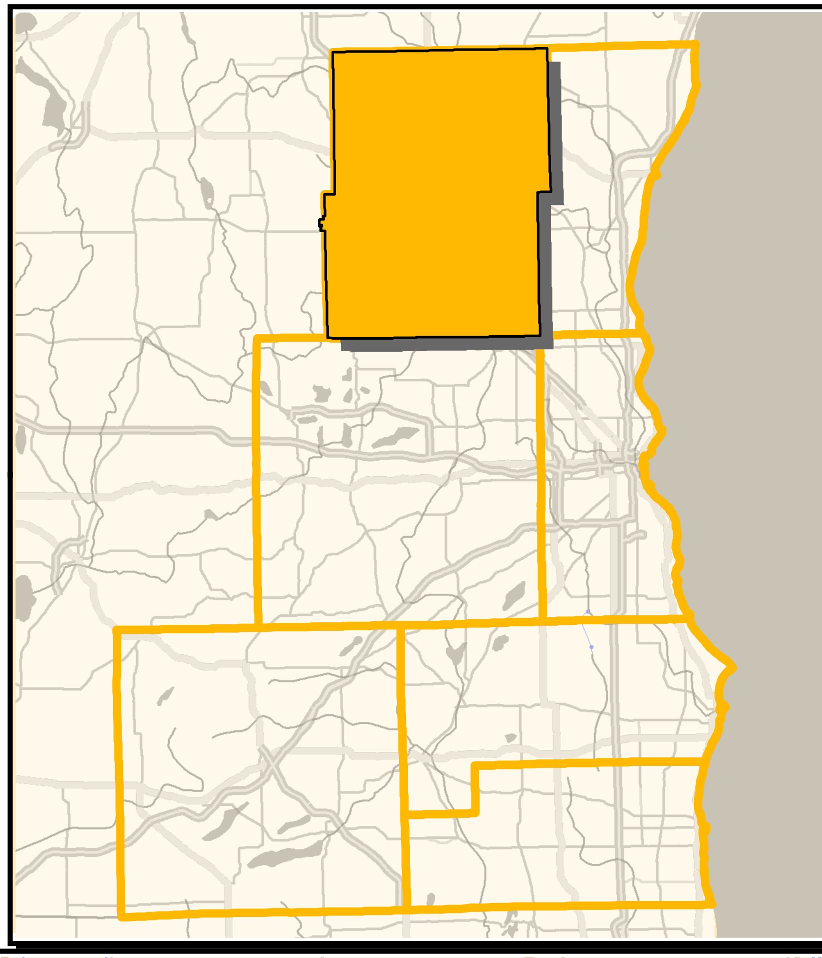


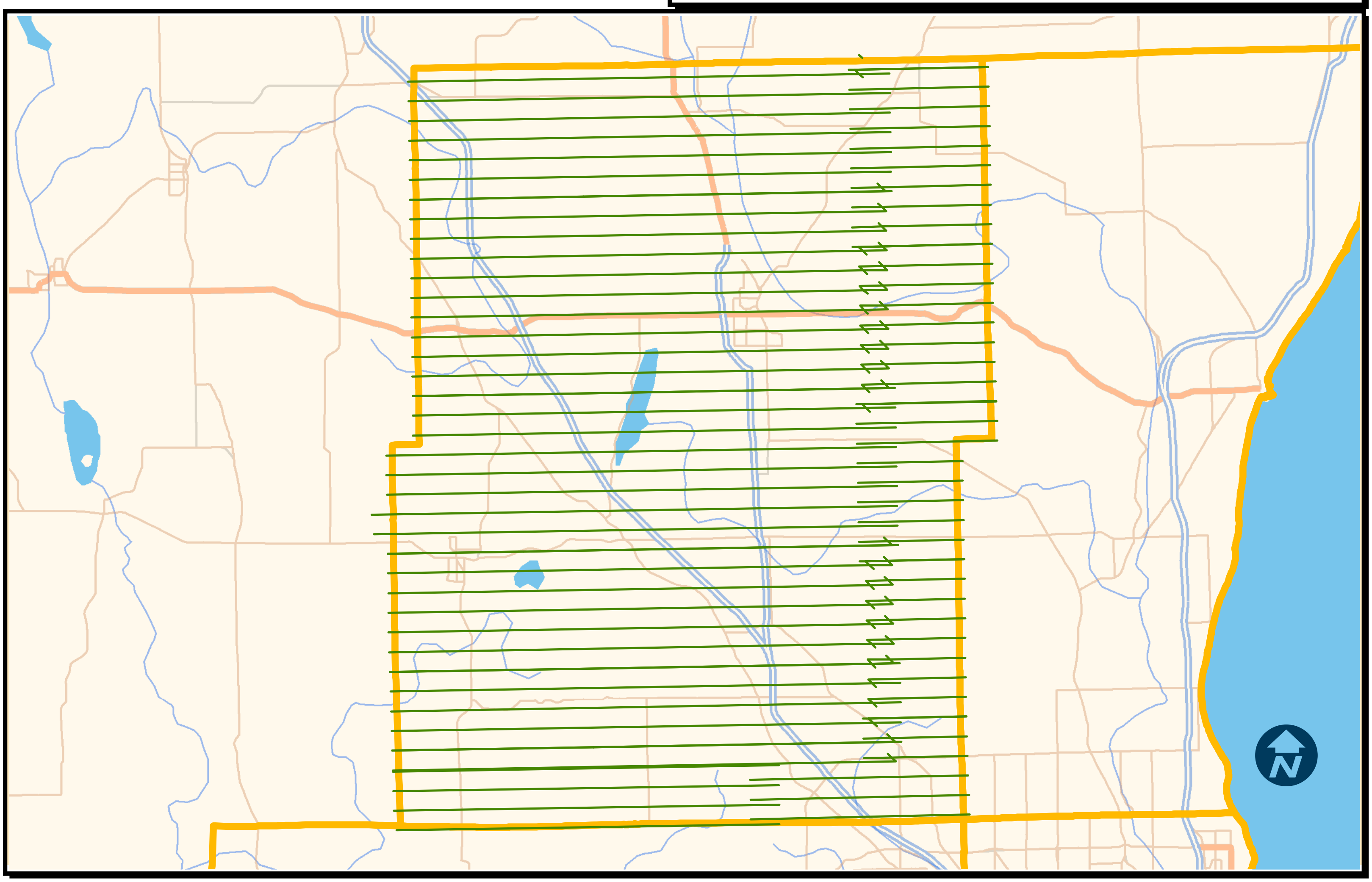
SE Wisconsin RPC Washington County Flight Plan 9-Inch Resolution

State: Wisconsin
County: Washington
Resolution: 9-Inch
Area (sqmi): 436
Length (mi): 1063.84
Hours: 14.388

Legend

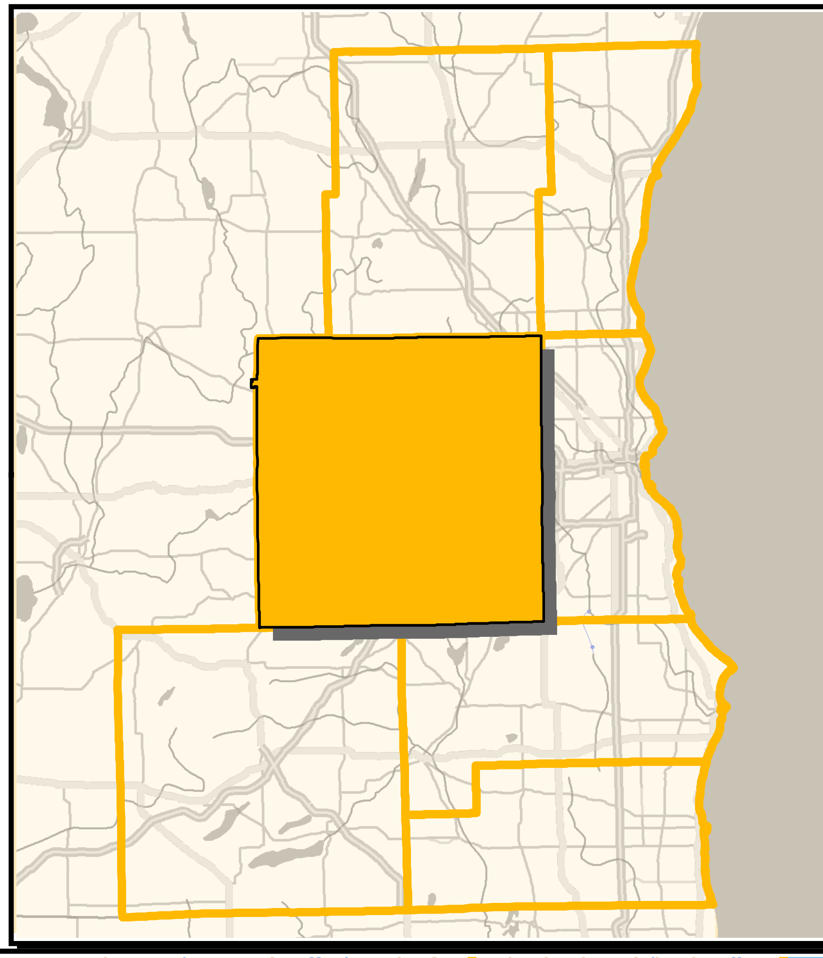
Washington 9-inch Flight Plan
County





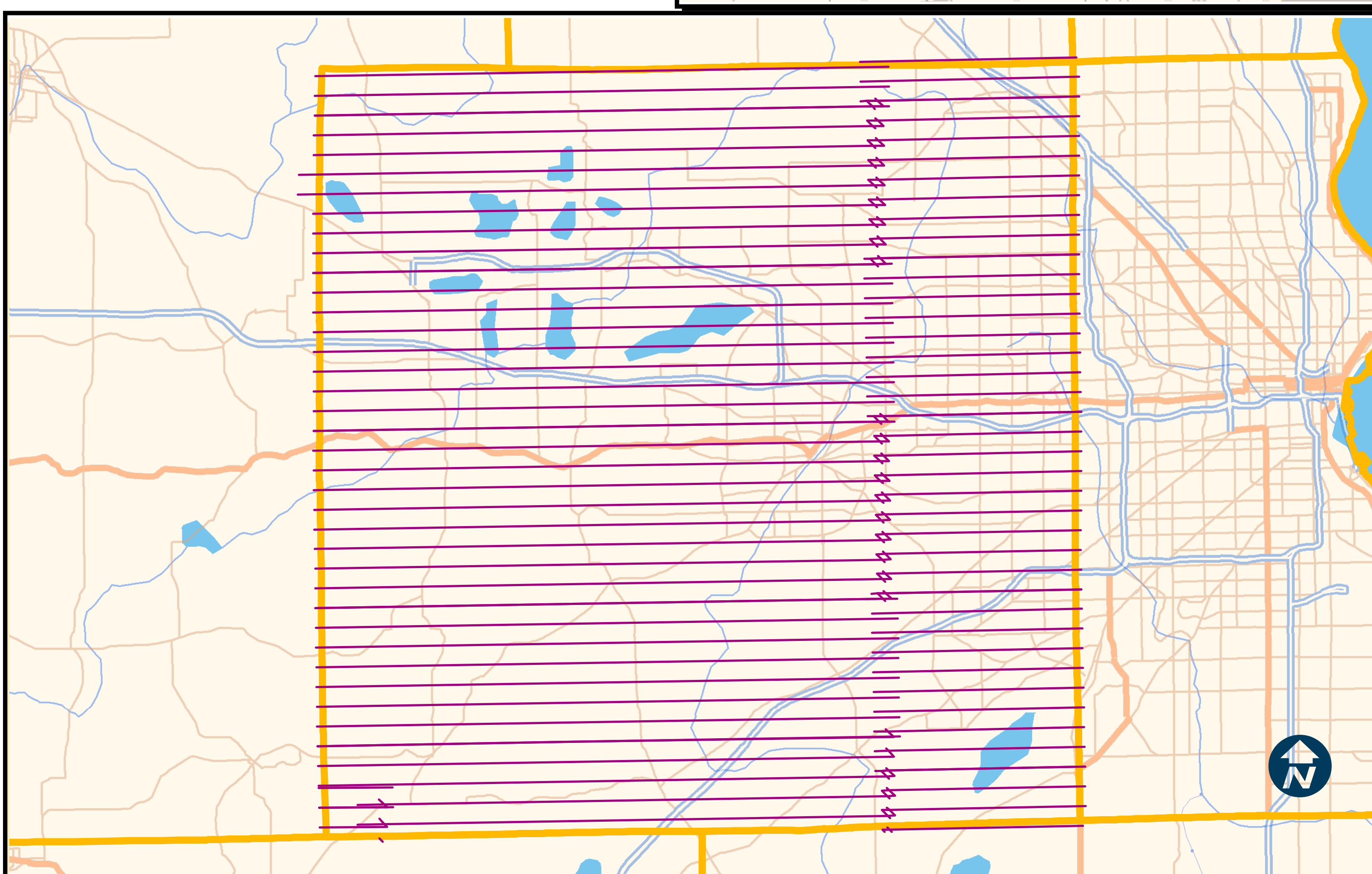
SE Wisconsin RPC
Waukesha County
Flight Plan
9-Inch Resolution

State: Wisconsin
County: Waukesha
Resolution: 9-Inch
Area (sqmi): 581
Length (mi): 2242.64
Hours: 29.478



Legend

Waukesha 9-inch Flight Plan
County



A
Pictometry International, Corp
White Paper

Relative Measurement Accuracies within Pictometry's Individual Orthogonal and Oblique Frame Imagery©

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Pictometry International, Corp

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AL, AZ, CA, CT, FL, GA, ID, LA, MS, NC, NM, NV, NY, ND, OR, SC, SD, TN, TX, USVI, WA, WI, WV
Geographic Information System Professional (GISP)
Nevada State Water Right Surveyor
Certified Federal Surveyor (CFedS)
NCEES Model Law Surveyor

Yandong Wang, PhD, CP
Director Photogrammetric Engineering
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January 02, 2014

Contents

Glossary

DEM	*Digital Elevation Model*
FOV	*Field Of View*
GPS	*Global Positioning System*
GSD	*Ground Sample Distance (a.k.a. Pixel size)*
GSE	*Ground Surface Error*
IMU	*Inertial Measurement Unit*
SBET	*Smoothed Best Estimate Trajectory*
PDOP	*Positional Dilution of Precision*
USGS	*United States Geological Survey*

Introduction

This paper will outline the procedures used, and the results of, the relative measurement accuracy calculations performed for individually captured orthogonal and oblique imagery frames.

Problem Statement

The goal of this paper is to provide a quantitative analysis of the relative measurement accuracies that can be obtained within individually captured orthogonal and oblique imagery frames.

Conclusion

It can be conservatively stated that the relative measurement accuracies which can be achieved when carefully measuring well-defined features within Pictometry's individually captured orthogonal and oblique frame imagery can be expressed in a simplified format as follows:

± (1.4 x GSD + 0.3% of distance measured)

Equipment and Software

Pictometry's Pentaview camera system is based on an architecture designed and patented by Pictometry. The Pentaview is a multi-camera system comprised of five digital camera modules and an acquisition computer (with sensor control hardware and software). Key components of the Pentaview system are manufactured and assembled by qualified suppliers under contract to Pictometry. Individual subsystems of the Pentaview system are integrated and tested at Pictometry's facilities in Rochester, NY. The finished camera system is calibrated and tested in the laboratory at Pictometry's facilities in Rochester, NY.

Pictometry's 16-megapixel Pentaview imaging system carries the *United States Geological Survey (USGS) Camera Type Certification* and comprises five custom designed cameras and an Applanix Position and Orientation System (POS) which includes both a Global Positioning System (GPS) antenna and an Inertial Measurement Unit (IMU). The five cameras are aimed with one looking nadir and four looking in each of the four cardinal oblique directions. Pictometry's 29-megapixel Pentaview imaging system is constructed on the USGS approved platform and incorporates upgraded 29-megapixel sensors.

As part of the manufacture, the individual cameras are put through a rigorous calibration process developed by Pictometry and licensed to the USGS. This process is used to solve for the camera's precise focal length, principal point location, and radial distortion coefficients. These parameters are then incorporated into the camera model.

Collection procedures

In advance of capturing the data, an additional aerial boresight calibration is performed on each of the systems involved in the project. An adjustment then is computed to solve for the alignment between the optical axis of the camera and the internal coordinate axes of the Inertial Measurement Unit (IMU). This adjustment is then applied to the imagery captured throughout the project. Each system completes a boresight flight at regular intervals to ensure that the sensors have stayed in alignment.

Once the cameras are calibrated and the system is aligned, data capture can begin. Throughout each of the capture missions, GPS/IMU data is logged on the aircraft, the GPS data is recorded at a minimum rate of 2Hz and the IMU data is logged at a minimum rate of 200Hz. Concurrently, one or more GPS reference stations are logging data on the ground. These reference stations may be either part of the NGS CORS network, or a base station set up and run by Pictometry or a licensed Surveyor sub-consultant.

The imagery is nominally captured with a PDOP value of less than 8.0 and no limitation on base line lengths other than being able to calculate a solution to the GPS vector. Due to the small format of Pictometry's camera, and automatic aerial triangulation techniques available, Pictometry limits its sensor to 6 degrees of pitch and yaw; this limit can be utilized due to the narrow field of view of Pictometry's cameras which, by design, limits the off-nadir distance of features at the edge of the frame.

Applanix POSPac software is utilized to post process the GPS/IMU data utilizing the SmartBase (IN-fusion) or single base station technology. The SmartBase technology uses a centralized filter approach to combine the GPS receiver's raw observables (psuedorange and phase observables) with the IMU data (tightly coupled solution). The Applanix SmartBase engine processes the raw observables (phase and psuedorange to each tracked satellite) from a minimum of four to a maximum of 50 continuously-working GPS reference stations surrounding the trajectory. The computed ionospheric, tropospheric, satellite clock, and orbital errors at all the reference stations are used to correct for the errors at the location of the remote receiver. The SmartBase Quality Check tool is utilized to perform a network adjustment on all the base-lines and reference stations in the network. Quality checks are also performed on the individual reference station observation files before the Applanix SmartBase is computed. The result of this process is that the integrity of the reference station's data and coordinates are known before the data is processed.

The single base technology is different as only one dedicated base station is used as a reference station and atmospheric delay and other correction data are only retrieved at the dedicated master station.

The final smoothed best estimated trajectory (SBET) is computed from the GPS track (including Kalman Filtering). Once the trajectory has been generated, it is applied to the imagery along with the camera model utilizing either the SmartBase or single base station modes.

Concurrent with the GPS/INS processing, the imagery in RAW format is "developed" to uncompressed TIFF format. After the development process, the imagery is put through a rigorous QA/QC process whereby images of low quality, due to either improper exposure or sensor artifact, are identified and marked for recapture. Pictometry uses both automated software it has created (proprietary) and human examination when considering whether to reject an image or pass it for production. Pictometry's Image Processing Department checks for any of dozens of possible defects while assessing the quality of the imagery.

The final approved imagery is put through a verification process wherein common points are compared in the images (tie-points). The calculated coordinates for each tie-point are then checked against those from the other tie-points of the same point in different images. Any anomalous points are investigated to ensure the tie-point is valid and the image data is reprocessed if necessary.

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Standard Product Relative Measurement Accuracies

Background

The relative measurement accuracy (between well-identified features) within an individual frame of Pictometry imagery depends on a number of factors. Among these are the accuracy of point location within the image, the accuracy of the digital elevation model (DEM) used for rectification, and the accuracy of the exposure station coordinates and orientation of the sensor at the time of the exposure (Exterior Orientation Parameters). The Position and Orientation System (POS) data provides the Exterior Orientation Parameters of the sensor at the time of exposure in a ground coordinate system. These parameters (commonly referred to as EOs) are primarily derived from the post-processed POS solution, the accuracy of which in turn depends upon the accuracy of the GPS reference station coordinates and the solved vector to the capture system.

The absolute horizontal accuracy of individual pixels as measured within individual orthogonal frames is dependent primarily upon the accuracy of the POS solution. While absolute horizontal accuracy comes into play when making distance measurements across image frames, the absolute horizontal accuracy has minimal effect on the overall accuracy of distance measurements within a single image frame – the only impact is the correlation of the image to the digital elevation model. Since Pictometry's absolute horizontal accuracy is typically less than the point spacing of the digital elevation model utilized, this contribution to error is negligible except in areas of extreme terrain variability.

For distance measurements within an individual frame (relative measurements), absolute vertical errors have a larger contribution to measurement errors than do absolute horizontal errors. The primary effect of absolute vertical errors on relative measurements is to alter the effective scale of the image. Since this change of scale, as a percentage, is based on the amount of absolute vertical error divided by the height over ground at which the image was captured, even a larger absolute vertical error, such as is seen with publically available sources (typical GSE ±7m/±20 feet), results in a relatively minor contribution to error when compared to a typical flying altitude of 3,500-feet over ground.

Relative Measurement Accuracies in Oblique and Orthogonal Imagery

The relative (measurement within a single frame) accuracy within individual orthogonal imagery frames is generally independent of the accuracy of an acceptable POS solution as the error in X, Y, and Z position only causes the shift of the image and will not propagate a significant error in ground measured distances within individual image frames. For oblique imagery an error in the X, Y, and Z position creates an error in the distance measurement due to the projection of the field of view across a DEM that contains some errors. Therefore the accuracy of DEM plays a very important role in determining the accuracy of distance measurement on Pictometry's oblique imagery.

The effect of DEM error: (see **Figure 1**)

DEM error is caused by the projection of the line of sight from the camera to its intersection with the calculated DEM which differs from the calculated intersection of the cameras line of sight with the true surface. For a course DEM with an accuracy of ±7m (±23-feet) this represents a scale error of 0.65% for images captured from 3,500-feet over ground as is typical for Pictometry's 4-inch GSD product, or about 7-feet on a distance measured over 1,000-feet. For error estimation, we combine the other scale-based effects and estimate the total scale-based error to be 1% of the distance measured.

For a finer resolution DEM with an accuracy of ±1m (±3-feet) this represents a scale error of 0.08% for images captured from 3,500-feet over ground as is typical for Pictometry's 4-inch GSD product, or about 1-foot on a distance measured over 1,000-feet. For error estimation, we combine the other scale-based effects and estimate the total scale-based error to be 0.3% of the distance measured.

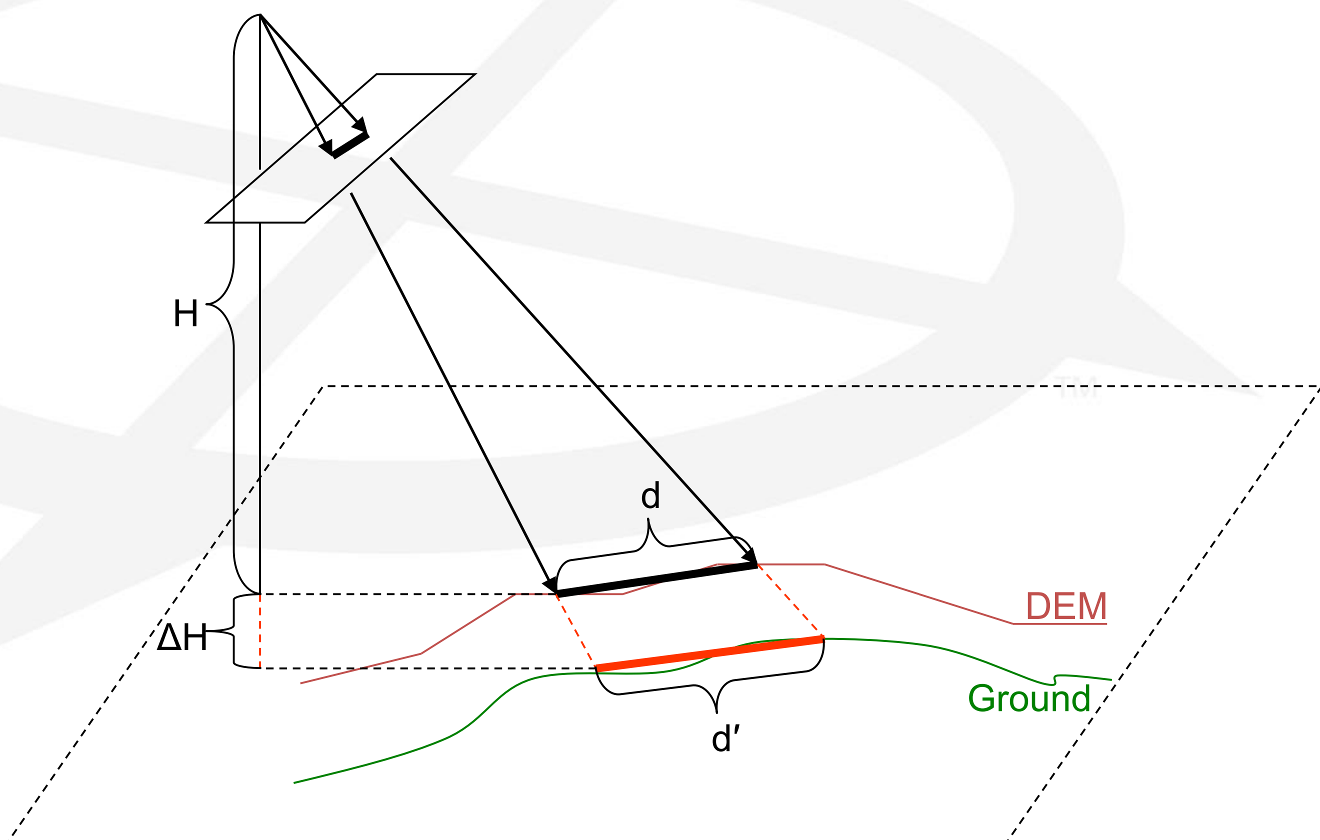

Figure 1 - Effect of DEM measurement on Distance measurement

The effect of GPS error: (see **Figure 2**)

GPS provides the position of the sensor at exposure time in a ground coordinate system. The error in X and Y only causes the shift of the image and does not cause the change in distance measurement. Figure 1 shows the change caused by GPS error in Z (ΔZ). The change of distance on the ground is:

$$\Delta d = d^{'} - d$$

For Pictometry's 6-inch oblique imagery, the error of distance measurement caused by GPS error is calculated to be nominally 4 inches for a distance of 1000 feet when GPS error is 1 foot, assuming terrain is flat.

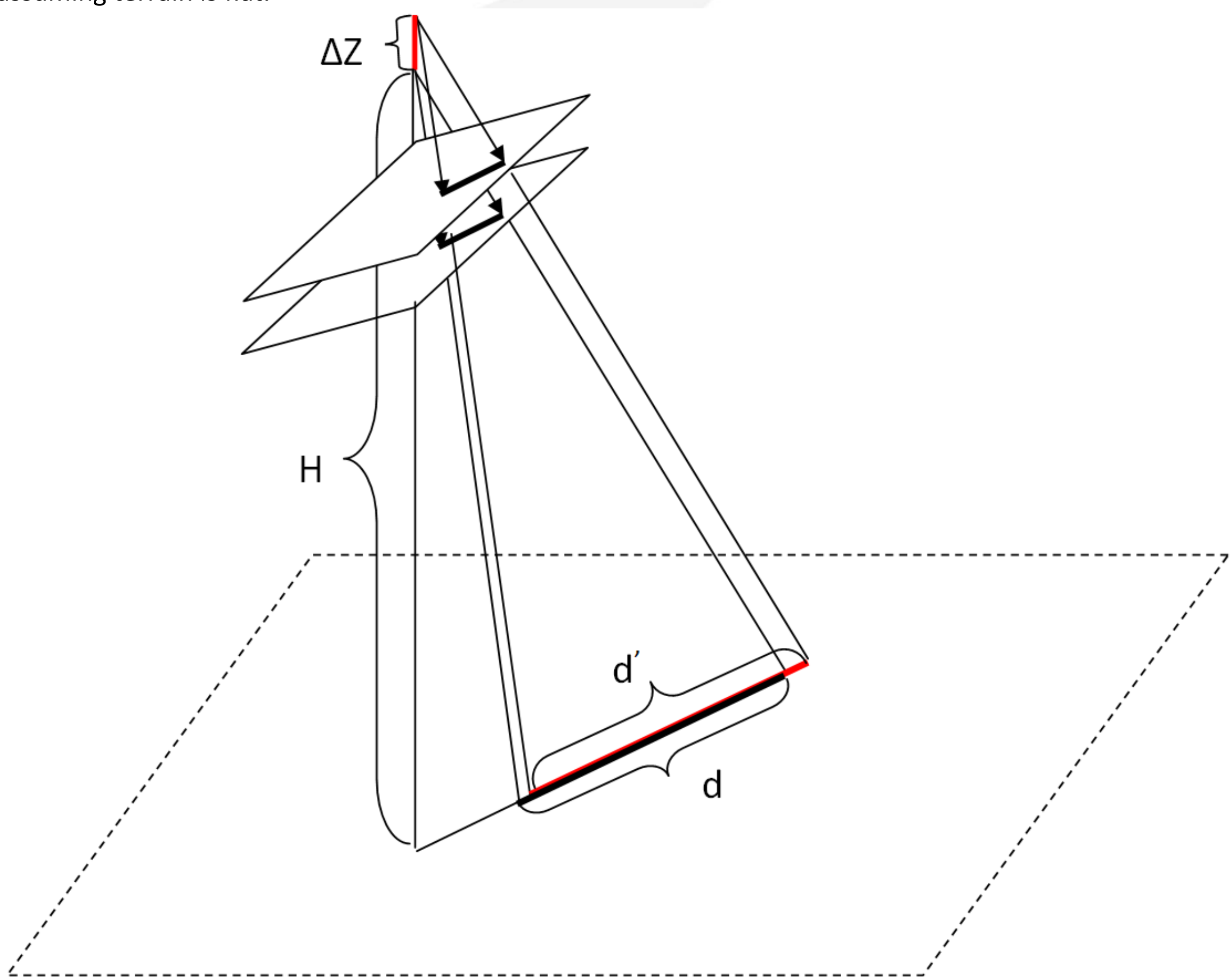

Figure 2 - Effect of GPS error on Distance measurement

The effect of IMU error: (see **Figure 3**)

Like GPS error, the error in IMU data affects the accuracy of distance measurement on Pictometry's oblique imagery as shown in Figure 3.

When the error in IMU is 0.015 degree, the change of distance on the ground Δd is calculated to ne nominally 3 inches for a distance of 1000 ft, assuming terrain is flat.

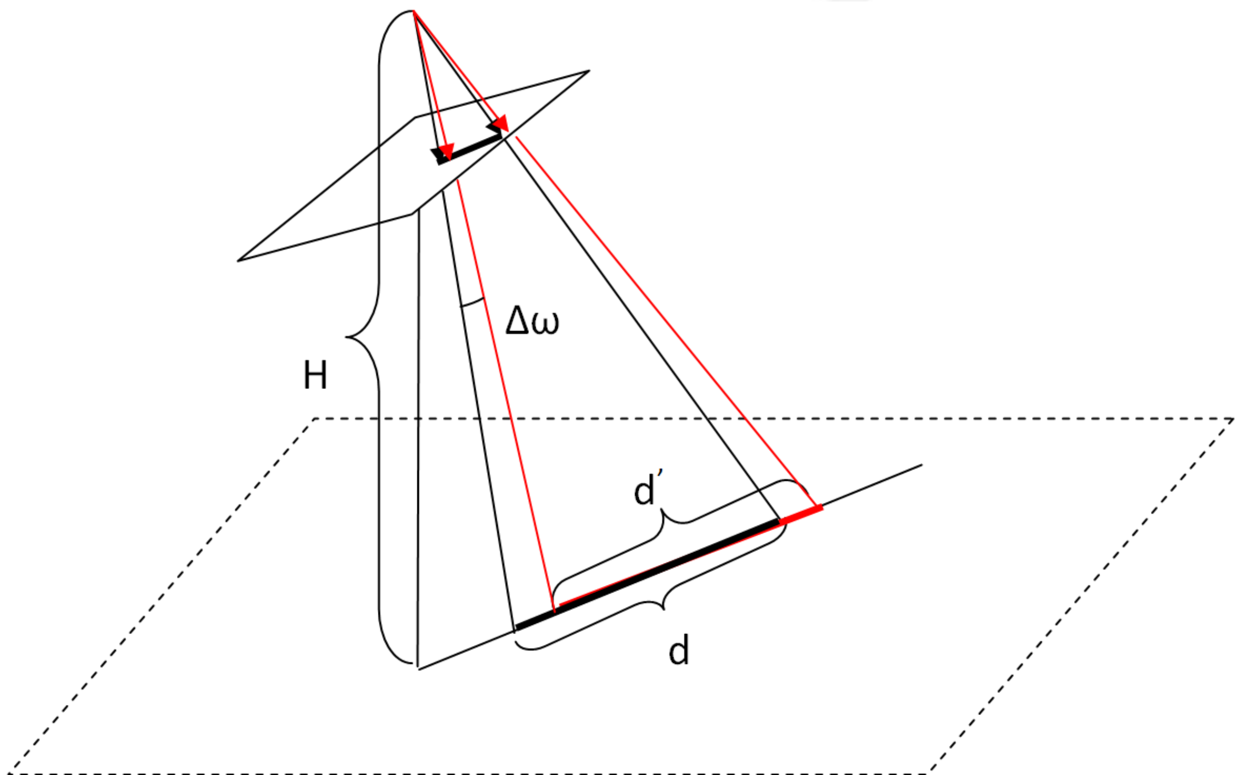

Figure 3 - Effect of IMU Error on Distance Measurement

The effect of "selection" error:

Another significant error is created by the "selection" of the desired points (on each end of the line measured) within the actually imagery frame. Assuming one can only "select" any given point to within 0.5 of the size of any given pixel, the "selection" error can be represented as follows:

$$Selection\ Error\ (estimated\ at 1\ pixel\ on\ 2\ sides\ of\ line\ measured)$$

$$= \sqrt{(GSD)^2 + (GSD)^2}$$

Summary

The effect of GPS and IMU sources of error were found to have minimal contribution to the overall relative distance measurements errors when compared against the calculated DEM and selection errors. The accuracies of linear measurements within individually captured imagery frames can therefore be expressed as two main components; the selection error which is directly related to pixel size (GSD) and scale error which is related to the accuracy of the DEM and the length of the line measured. The selection error is a constant value based directly on the GSD of the imagery and is the most significant source of error in measurement of shorter distances. The scale error is directly related to the quality of the Digital Elevation Model (DEM) utilized and is the most significant source of error in measurements of long distances

A standard error analysis formula can therefore be expressed by the following formula:

Distance error = $\sqrt{\sigma(picking\ error)^2 + \sigma(scale\ error)^2}$

Relative Measurement Accuracies

The relative measurement accuracies which can be achieved, when carefully measuring well-defined features within Pictometry's individually captured orthogonal and oblique frame imagery, can be expressed in a simplified format as follows:

± (1.4 x GSD + 0.3% of distance measured)

This equates to the following relative measurement accuracies for a DEM having an estimated error of ± 3 feet [1m]:

3-inch [7.5 cm] GSD Imagery	=	± (0.35 feet [11 cm]	+ 0.3% of distance measured)
4-inch [10 cm] GSD Imagery	=	± (0.47 feet [14 cm]	+ 0.3% of distance measured)
6-inch [15 cm] GSD Imagery	=	± (0.70 feet [21 cm]	+ 0.3% of distance measured)
9-inch [22.5 cm] GSD Imagery	=	± (1.05 feet [32 cm]	+ 0.3% of distance measured)
12-inch [30 cm] GSD Imagery	=	± (1.40 feet [42 cm]	+ 0.3% of distance measured)