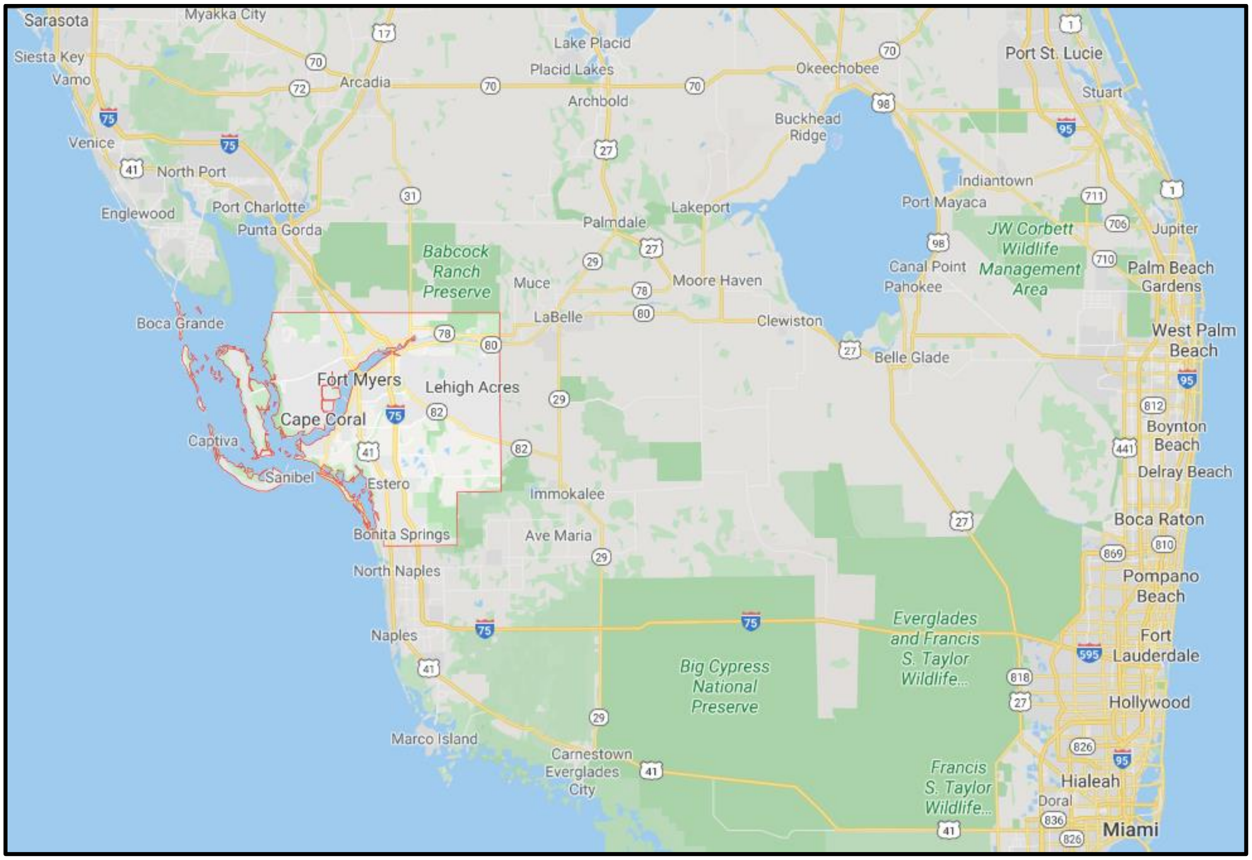
Report for 2021 Ortho & Oblique Imagery

Prepared for:

Lee County, Florida



map not to scale

Prepared by:

Pictometry International Corp.

25 Methodist Hill Drive

Rochester, NY 14623

Phone 585-486-0093 / Fax 585-486-0098

Pictometry Business License No. LB7711

This report is not valid without the signature and the digital signature of a Florida licensed Professional Surveyor and Mapper. "I CERTIFY TO THE BEST OF MY KNOWLEDGE AND BELIEF THAT THIS DIGITAL ORTHOPHOTOGRAPHY MAP MEETS OR EXCEEDS THE CONTRACT REQUIREMENTS AND THE STANDARDS OF PRACTICE APPLICABLE FOR THIS WORK."

CLAIRE KIEDROWSKI License Number 6723 STATE OF FLORIDA Professional Surveyor and Mapper

Digitally signed by Claire E Kiedrowski Date: 2021.06.04 16:32:00 -04'00'

Claire Kiedrowski – Senior Photogrammetrist, FL PSM #6723 Date: June 4, 2021

Table of Contents

Introduction

This report pertains to the Photogrammetric Mapping and Digital Aerial Color Orthophotography and Oblique photography processing performed to produce the georeferenced orthogonal and oblique imagery, as delivered to the client, Lee County, FL. This document includes, but is not limited to, the **Orthoimage Specifications** as listed in the ***2019 Florida County Digital Orthoimagery Program Standards (October 18, 2019).*** All work was performed in accordance with the ***Standards of Practice*** as set forth in ***Rule Chapter 5J-17, F.A.C.***, pursuant to ***Chapter 472, F.S.***

Project Area

This report encompasses approximately 1,068 square miles of 3-inch Ortho & Oblique imagery within Lee County, Florida.

Projection

State Plane Coordinate System 1983
Florida West Zone
North American Datum 1983 (2011)
NAVD88
US Survey Feet

Capture Window

Imagery was obtained between the dates of January 4, 2021 – February 4, 2021.

Digital Media

In addition to this Report, the project delivery is only complete upon receiving an external hard drive labeled: **FLLEE21.**

Office Personnel

Claire Kiedrowski – Professional Surveyor & Mapper, FL PSM License #6723
Margaret Myers – Project Manager
Chris Clar – Director, Geomatics & Photogrammetric Production
Thaddeus Hagood – Geomatics Manager
Emma Witherwax – AT Specialist
Nick Gagne – Mosaic Specialist

Professional Surveyor & Mapper

Unless otherwise noted, the scope of responsibility for the licensed professional referenced herein, is limited to the following: review and validation of the aerial data collection methodologies concepts and procedures utilized for the project; review of GPS/INS post-processing solution(s); review and validation of testing methodologies/procedures utilized to represent any accuracy statements shown herein; planning of the locations of any ground control points to be used in aerial triangulation tasks; supervision of any aerial triangulation production tasks; review and approval of DEM preparation procedures utilized to support the orthorectification of any certified orthomosaic products; preparation of the initial aero-triangulated and orthorectified mosaic utilized as the data source for any additional corrections (e.g. color/tonal balancing and individual feature correction).

LICENSED SURVEYOR & MAPPER **Claire Kiedrowski PSM #6723**

Captured Raw Data Summary

This report is complete with the accompanying external hard drives containing the digital orthophotography imagery frame mapping data.

Deliverable Information

Produced GSD	Average GSD of Source Frame	Total Area (Square Mile)
3-inch Ortho	2.59 Inches	1,068
3-inch Oblique	2.51 Inches	1,068

Tile Projection

System	Datum	Zone	Units
US State Plane 1983	North American Datum 1983 - 2011	Florida West Zone	US Survey Feet

Flight Log

Capture ID: FLLEE016

Flight Plan Name	Flight Plan Complete Date	Time (Hrs.)	Flight Altitude MSL (USft)	Rig Type
FLLEE_FP301	1/4/2021	2.45	2501	N5
FLLEE_FP302	1/7/2021	2.16	2501	N5
FLLEE_FP303	1/7/2021	2.16	2501	N5
FLLEE_FP304	1/14/2021	2.16	2501	N5
FLLEE_FP305	1/15/2021	2.16	2501	N5
FLLEE_FP306	1/7/2021	2.16	2501	N5
FLLEE_FP307	1/10/2021	2.16	2501	N5
FLLEE_FP308	1/10/2021	2.02	2601	N5
FLLEE_FP309	1/15/2021	2.03	2601	N5
FLLEE_FP310	1/17/2021	2.32	2501	N5
FLLEE_FP311	1/10/2021	2.32	2501	N5
FLLEE_FP312	1/18/2021	2.32	2501	N5
FLLEE_FP313	1/5/2021	2.32	2501	N5
FLLEE_FP314	1/6/2021	2.32	2501	N5
FLLEE_FP315	1/5/2021	2.32	2501	N5
FLLEE_FP316	1/6/2021	2.32	2501	N5
FLLEE_FP317	1/6/2021	2.32	2501	N5
FLLEE_FP318	1/10/2021	2.32	2501	N5
FLLEE_FP319	1/10/2021	2.32	2501	N5
FLLEE_FP320	1/15/2021	2.32	2501	N5
FLLEE_FP321	1/15/2021	2.32	2501	N5
FLLEE_FP322	1/6/2021	2.32	2501	N5
FLLEE_FP323	1/17/2021	2.32	2501	N5
FLLEE_FP324	1/17/2021	2.32	2501	N5
FLLEE_FP325	1/17/2021	2.32	2501	N5
FLLEE_FP326	1/17/2021	2.32	2501	N5
FLLEE_FP327	1/17/2021	2.32	2501	N5
FLLEE_FP328	1/17/2021	2.32	2501	N5
FLLEE_FP329	1/15/2021	2.48	2501	N5
FLLEE_FP330	1/5/2021	2.24	2501	N5
FLLEE_FP331	1/11/2021	2.35	2501	N5
FLLEE_FP332	1/10/2021	2.23	2501	N5
FLLEE_FP333	1/5/2021	1.75	2501	N5
FLLEE_FP351	1/19/2021	2.22	4501	Hubble
FLLEE_FP352	1/20/2021	2.28	4501	Hubble
FLLEE_FP353	1/20/2021	2.23	4501	Hubble
FLLEE_FP354	1/21/2021	2.22	4501	Hubble
FLLEE_FP355	1/21/2021	2.17	4501	Hubble
FLLEE_FP356	1/22/2021	2.14	4501	Hubble
FLLEE_FP357	1/28/2021	2.14	4501	Hubble
FLLEE_FP358	2/3/2021	2.14	4501	Hubble
FLLEE_FP359	2/4/2021	2.14	4501	Hubble
FLLEE_FP360	2/4/2021	2.14	4501	Hubble
FLLEE_FP361	1/28/2021	1.89	4501	Hubble
FLLEE_FP362	1/29/2021	2.01	4501	Hubble
FLLEE_FP363	1/29/2021	1.89	4501	Hubble
FLLEE_FP364	2/3/2021	1.92	4501	Hubble
FLLEE_FP901	1/5/2021	0.57	2501	N5
FLLEE_FP902	1/6/2021	0.37	2601	N5
FLLEE_FP903	1/6/2021	1.22	2501	N5
FLLEE_FP951	1/28/2021	0.64	4501	Hubble
FLLEE_FP952	1/28/2021	0.39	4501	Hubble

Flight Plan Map

Flight Operations Department:
Scott Martin: 585-317-3385
Dan Applegate: 585-490-3146
Cale Holden: 585-734-3814

Pilot Contact Information

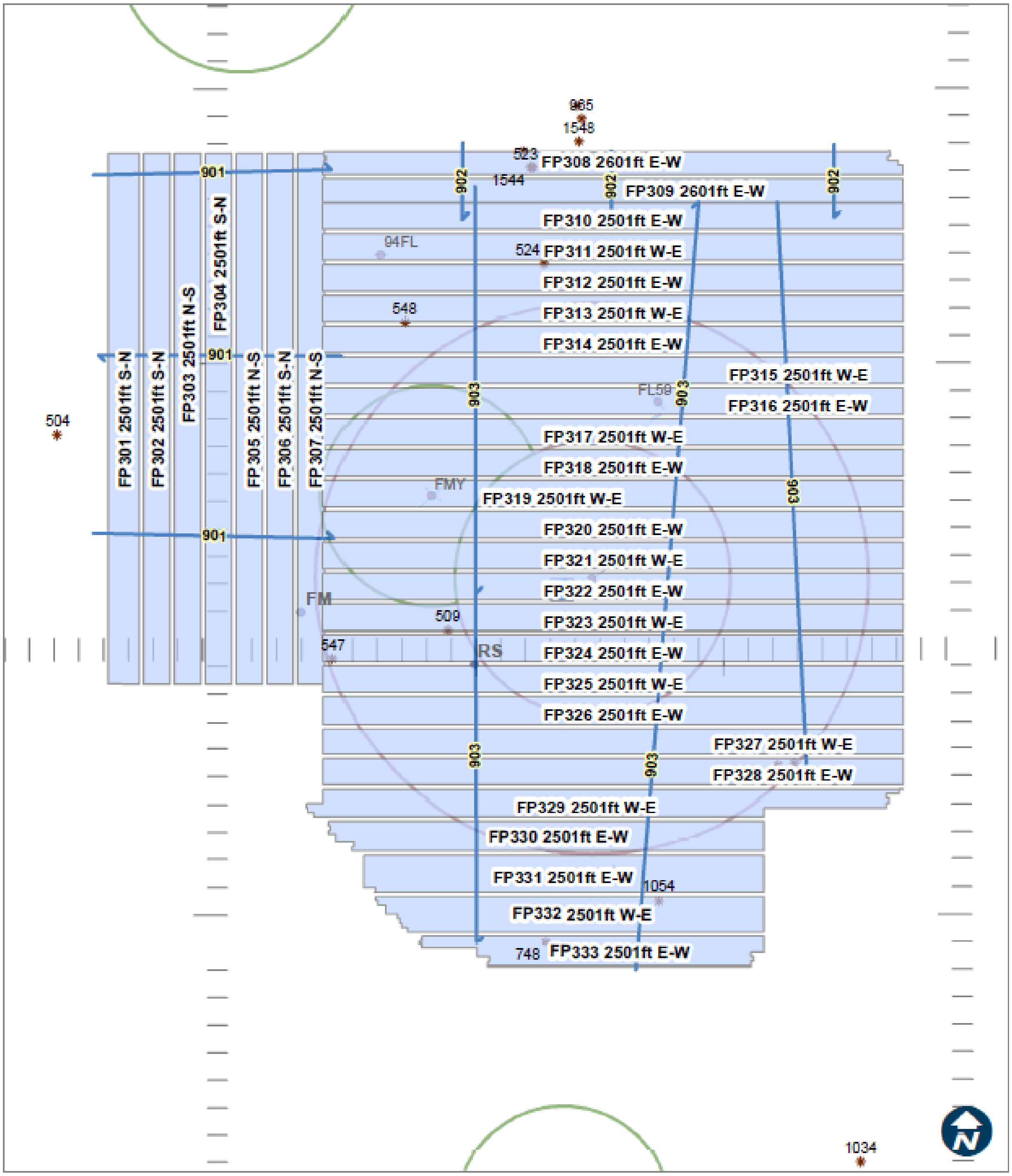
Name:

Tail Number:

Local Phone:

FLLEE016

N5 AccuPlus
FP301-333
FP901-903



Please note that Pictometry is now doing business under the EagleView brand name eagleview

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Pilot Contact Information

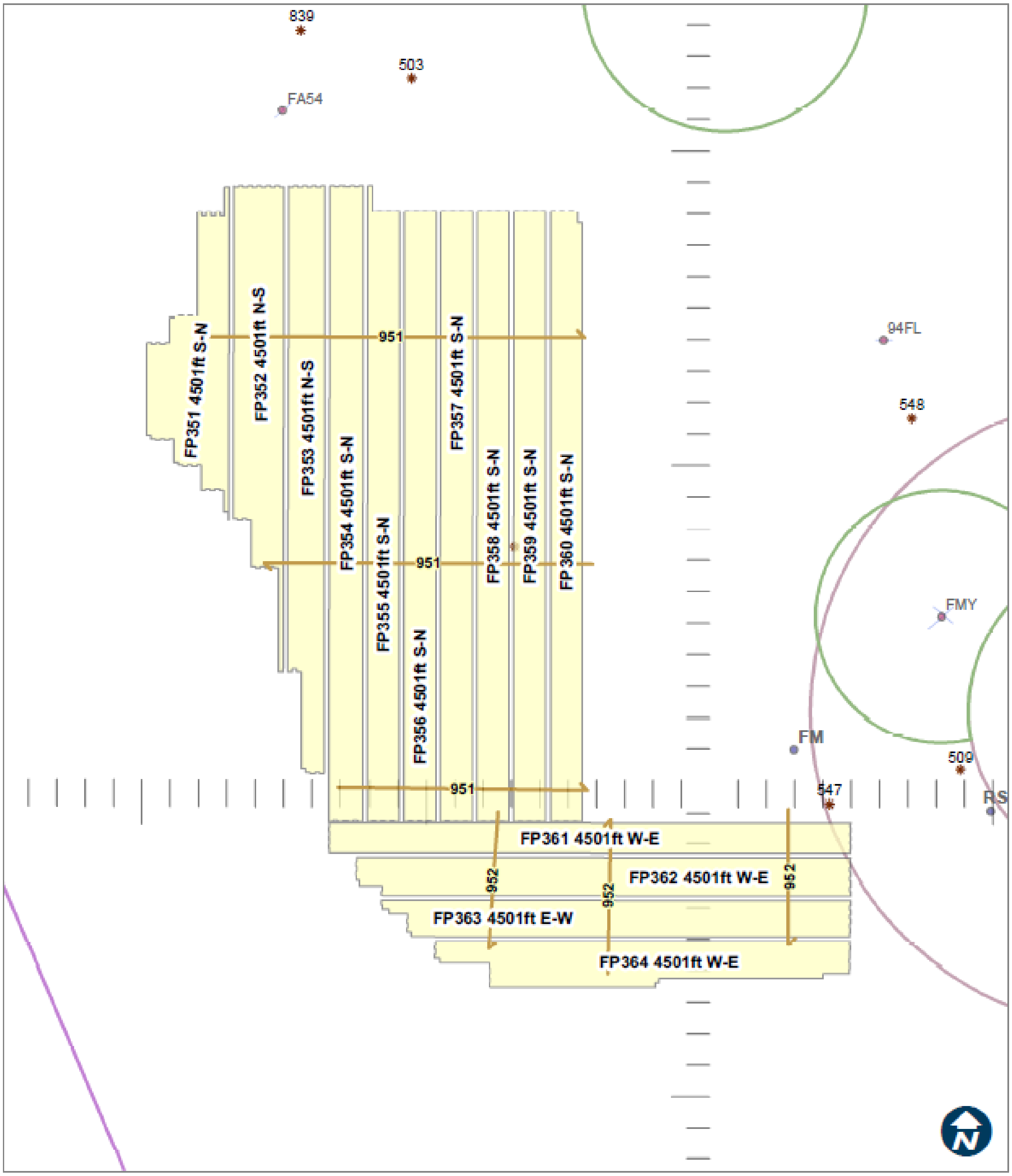
Name:

Tail Number:

Local Phone:

FLLEE016

N5 Hubble AccuPlus
FP351-364
FP951-952



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Surveyed Ground Control

Ground control points were established to support orthoimage mapping. All control meets the requirements of the FCDOP, and directly referenced to the FPRN. Data conforms to Florida Standards of Practice 5J-17, F.A.C. *The formal signed and digitally sealed survey report accompanying this report includes survey details required by **2019 Florida County Digital Orthoimagery Program Standards (October 18, 2019)**.*

Source

Company: GeoPoint Surveying, Inc.
License Business Number: 7768
Supervising Surveyor: James D. LeViner, PSM LS6915
Field Dates: January 16-27, 2020

Ground Control Points constrained during AT:

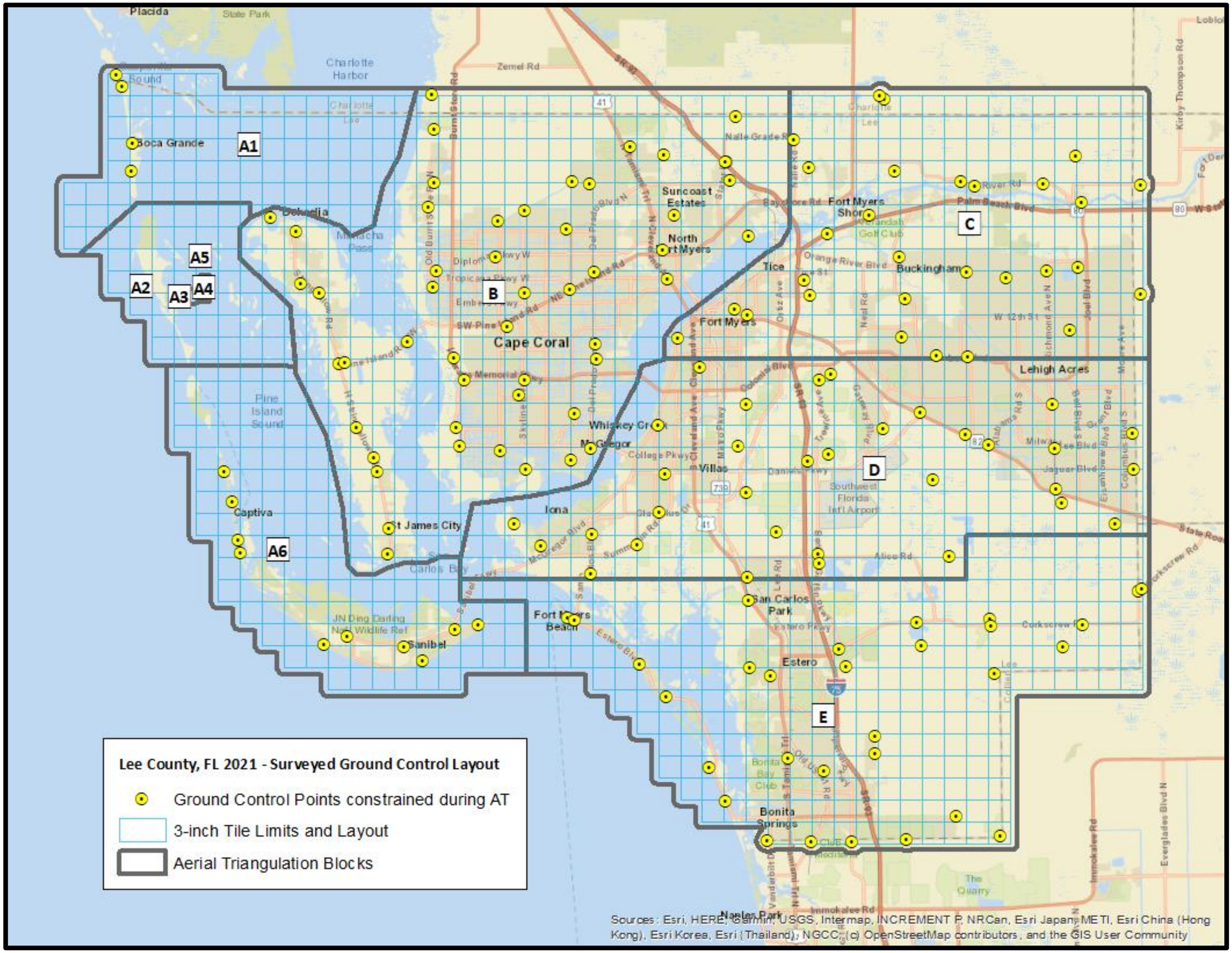
Point ID	NAD83(2011) / SPCS83 - FL West		NAVD88-Geoid18	Description
	Northing (usft)	Easting (usft)	Ortho (usft)	
63544	809820.536	780309.056	27.873	Concrete
63543	771238.824	669533.821	3.427	Concrete
63542	770683.629	671150.208	3.046	Concrete
63541	753276.348	692057.026	4.699	Concrete
63540	760853.408	685905.162	3.536	Concrete
63539	729600.785	705476.246	4.488	Concrete
63538	737352.302	701790.249	4.071	Concrete
63537	885244.599	707660.479	25.252	Concrete
63536	874880.070	705575.211	21.582	Concrete
63535	874896.497	705354.220	23.547	Concrete
63534	870623.402	706381.120	16.466	Concrete
63533	857994.098	710543.240	4.160	Concrete
63532	873584.124	724425.045	19.839	Concrete
63531	879966.938	720886.033	23.354	Concrete
63530	889104.838	741584.674	28.097	Concrete
63529	889996.526	740505.505	29.434	Concrete
63528	865756.651	786406.670	14.104	Concrete
63527	869665.812	799777.426	17.690	Paint
63526	876132.435	784850.685	19.665	Concrete
63525	869761.214	777659.376	9.452	Paint
63524	869247.625	762122.251	11.394	Concrete
63523	870316.455	758823.405	15.038	Concrete
63522	872736.702	743931.466	8.990	Concrete
63521	858495.703	728582.967	9.051	Concrete
63520	862655.455	738069.147	9.088	Concrete
63519	853210.719	744929.090	11.982	Concrete
63518	848599.402	769077.955	18.375	Concrete
63517	849894.596	760098.024	18.047	Concrete
63516	850900.125	785435.438	18.977	Concrete
63515	850091.612	778508.808	19.188	Concrete
63514	844945.167	799685.238	23.446	Concrete
63513	836686.752	783693.403	22.777	Concrete
63511	830468.391	760568.277	25.516	Concrete
63510	830753.807	753306.047	23.999	Concrete
63509	843872.965	746149.933	17.322	Concrete
63508	835093.807	745423.245	22.313	Concrete
63507	847965.133	723437.442	16.887	Concrete
63506	844564.985	724540.265	20.277	Concrete
63505	720444.688	724915.421	15.703	Concrete
63504	720834.309	714954.501	9.470	Metal Grate
63503	720356.656	734053.483	15.747	Concrete

63502	726389.537	757736.075	16.488	Paint
63501	721018.037	746451.786	14.274	Concrete
63500	721833.478	767748.016	17.498	Concrete
63499	740423.984	739408.164	14.682	Concrete
63498	744491.857	739269.829	14.439	Concrete
63497	736560.104	727884.327	11.864	Concrete
63496	739357.211	719625.761	8.299	Concrete
63495	785280.803	756265.841	26.688	Paint
63494	770206.165	748973.424	20.774	Concrete
63493	765063.004	749920.548	18.991	Concrete
63492	764174.482	731351.153	17.700	Concrete
63491	760182.550	732895.639	17.691	Concrete
63490	758244.240	715589.732	13.363	Concrete
63489	760050.900	710998.831	11.152	Concrete
63488	775355.484	710621.382	10.707	Concrete
63487	790767.271	717026.981	18.006	Concrete
63486	780616.268	710510.503	10.397	Concrete
63485	785785.083	726508.643	22.599	Paint
63484	783670.887	726840.765	21.338	Concrete
63483	806834.288	724028.404	23.358	Concrete
63482	808344.286	728778.788	23.754	Concrete
63481	810241.366	708225.899	14.521	Concrete
63480	799680.591	710023.302	15.035	Concrete
63479	771103.904	765435.924	28.175	Concrete
63478	769515.865	765861.502	25.110	Concrete
63477	758606.617	766509.612	20.412	Concrete
63476	764712.364	782045.613	28.001	Concrete
63475	769774.066	786578.114	29.036	Paint
63474	777361.769	799088.553	29.479	Paint
63473	777995.033	799920.399	27.619	Paint
63472	792723.977	794037.339	28.006	Concrete
63471	800590.457	780518.582	28.815	Concrete
63470	797475.822	781749.253	29.763	Concrete
63469	813317.345	797990.003	27.849	Concrete
63468	805163.757	798054.458	29.217	Concrete
63466	819854.170	779580.901	27.195	Concrete
63465	812977.654	759951.100	27.194	Concrete
63464	810461.763	765094.238	27.454	Concrete
63463	802692.276	752635.977	27.347	Concrete
63462	814318.209	741294.989	26.673	Concrete
63461	818076.986	749612.002	25.791	Concrete
63460	825350.729	726695.586	23.533	Concrete
63459	826665.540	729246.480	21.191	Concrete
63458	879109.561	570680.918	5.699	Concrete
63457	872734.986	570485.985	5.367	Concrete
63456	894725.264	567216.228	5.993	Paint
63455	892030.568	568324.990	3.019	Concrete
63454	804424.005	591616.038	3.475	Concrete
63453	797542.983	593406.013	3.188	Concrete
63452	788968.710	594733.328	6.448	Concrete
63451	786122.026	595337.890	4.353	Concrete
63450	767200.497	619580.420	3.490	Paint
63449	765265.262	614325.384	5.257	Concrete
63448	764778.539	632428.389	4.261	Concrete
63447	761673.801	636737.015	4.124	Concrete
63446	768684.174	644034.074	5.814	Concrete
63445	769686.663	649332.247	4.371	Concrete
63444	787964.503	685310.903	6.613	Concrete
63442	787697.839	663519.174	7.200	Concrete
63441	792778.519	657435.938	4.770	Concrete
63440	781307.308	674752.070	4.676	Concrete

63439	790208.950	675104.524	7.387	Concrete
63438	804001.938	691603.690	5.425	Concrete
63437	795253.259	690475.359	3.832	Concrete
63436	815143.556	690116.520	5.536	Concrete
63435	819666.157	710183.655	15.964	Concrete
63434	841400.076	707503.798	12.619	Concrete
63433	839970.865	710276.738	16.322	Concrete
63432	848137.160	692098.754	6.647	Concrete
63431	828297.662	699493.537	13.628	Concrete
63430	834821.971	694605.706	5.018	Concrete
63429	791530.919	628967.395	4.671	Concrete
63428	785786.582	628605.199	4.588	Concrete
63427	804574.586	626443.129	6.817	Concrete
63426	814502.051	621747.093	7.182	Asphalt
63425	807732.792	625499.483	5.703	Concrete
63424	829021.113	617636.662	6.109	Concrete
63423	834063.683	633132.381	4.161	Concrete
63422	829256.376	619061.463	4.034	Concrete
63421	847104.046	608868.467	6.579	Concrete
63420	845149.316	613244.516	9.853	Concrete
63419	859117.968	607968.340	3.589	Concrete
63418	862226.020	602033.479	3.586	Concrete
63417	814598.985	644244.168	4.510	Concrete
63416	809158.703	654313.735	4.307	Concrete
63415	810275.932	644960.839	5.781	Concrete
63414	821789.346	658380.795	8.113	Concrete
63413	825216.096	659701.813	8.109	Concrete
63412	807083.075	670254.246	3.426	Concrete
63411	804960.669	660152.696	5.586	Concrete
63410	817656.086	671073.893	7.447	Concrete
63409	809657.895	674909.642	3.893	Concrete
63408	833502.720	675875.010	6.586	Concrete
63391	830102.074	676188.443	5.196	Concrete
63390	845868.650	670205.571	12.983	Concrete
63389	859549.676	669270.706	14.330	Concrete
63388	849909.688	675508.658	13.133	Concrete
63387	853323.804	653112.878	8.964	Concrete
63386	845145.515	659879.211	9.931	Concrete
63385	837562.966	655740.878	8.877	Concrete
63384	825333.887	646044.793	4.565	Concrete
63383	830348.283	643734.904	4.765	Concrete
63382	846395.402	639063.319	4.428	Concrete
63381	849975.253	639845.128	5.027	Concrete
63380	864448.884	638050.117	5.974	Concrete
63379	869991.706	639291.041	4.600	Concrete
63378	882123.036	639283.928	6.278	Concrete
63377	890066.733	638755.589	5.334	Concrete
63376	861301.393	653636.455	9.811	Concrete
63375	863898.500	659952.955	14.191	Concrete
63374	870276.825	670598.694	15.572	Concrete
63373	869878.510	674684.704	14.703	Concrete
63372	862610.811	693798.987	15.629	Concrete
63371	854941.285	691144.729	12.476	Concrete
63370	878223.611	683898.075	20.069	Concrete
63369	876326.403	691383.243	20.504	Concrete

Control was not located in AT Blocks A2, A3, A4 and A5 (the northwest portion of the project area), due to type of terrain (swamp and water), lack of developed hard surface features, and inability to place targets. In this area, we relied heavily on the airborne GPS and IMU data.

Surveyed Ground Control Distribution on AT Block Layout



Accuracy of Orthophotography

The orthoimagery products (referred to as the 'AccuPlus' orthomosaic) have been produced in accordance with the ***2019 Florida County Digital Orthoimagery Program Standards (October 18, 2019)***.

3-inch GSD

This data set data was compiled to meet ***ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014)*** for 0.50 foot (15.24 cm) RMSEx / RMSEy Horizontal Accuracy Class, which equates to +/- 1.25 feet (38.10 cm) NSSDA 95% confidence level.

Standard Process: Equipment and Software

Camera System

EagleView's Pentaview camera systems is based on architecture designed and patented by EagleView. The Pentaview camera system is a multi-camera system comprised of camera modules, an acquisition computer (with sensor control hardware and software) and an Applanix Position and Orientation System (POS) which includes both a Global Positioning System (GPS) antenna and an Inertial Measurement Unit (IMU). EagleView's Pentaview system is comprised of five cameras which are aimed with one looking nadir and one looking in each of the four cardinal oblique directions. Key components of the system are manufactured and assembled by qualified suppliers under contract to EagleView. Individual subsystems of the Pentaview system are integrated and tested at EagleView's facilities in Rochester, New York, as are all finished camera systems.

Manufacturing and Calibration

As part of the manufacturing and calibration process, EagleView's individual cameras are put through a rigorous calibration developed by EagleView 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 EagleView to generate a consistent response, ensuring consistent representation of ground features.

EagleView four band and color IR imagery is created through a composition of nadir (ortho) RGB imagery with near infrared (NIR) imagery. The NIR imagery is collected via a camera identical to the camera used in the Pentaview imaging system excepting the exclusion of a Bayer filter array and inclusion of a visible light blocking filter. The spectral sensitivity of the NIR camera ranges from approximately 690 to about 950 nm. Peak sensitivity is at the shortest wavelength. Exposure of the NIR camera is calibrated for green matched scene luminance of bare, dry earth.

EagleView IR cameras are calibrated using our same rigorous and USGS recognized methodology using spectrally matched illumination systems. In flight, the NIR is co-aimed with an RGB camera and captures images simultaneously using digital synchronization. Identical processing methods are used for RGB as NIR imagery. Each image is then independently geo-referenced before composition of the imagery.

Collection procedures

System Alignment

In advance of capturing the data, an additional aerial boresight calibration is performed on each of the systems involved in the project. An adjustment 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, 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 EagleView 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 EagleView's camera, and automatic aerial triangulation techniques available, EagleView limits its sensor to 6 degrees of pitch and yaw; this limit can be utilized due to the narrow field of view of EagleView's cameras which, by design, limits the off-nadir distance of features at the edge of the frame.

Imagery is 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%. During the capture process, EagleView'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. Upon completion of collection, the data is transferred to EagleView's processing facility in Rochester, NY.

GPS/INS Post-Processing

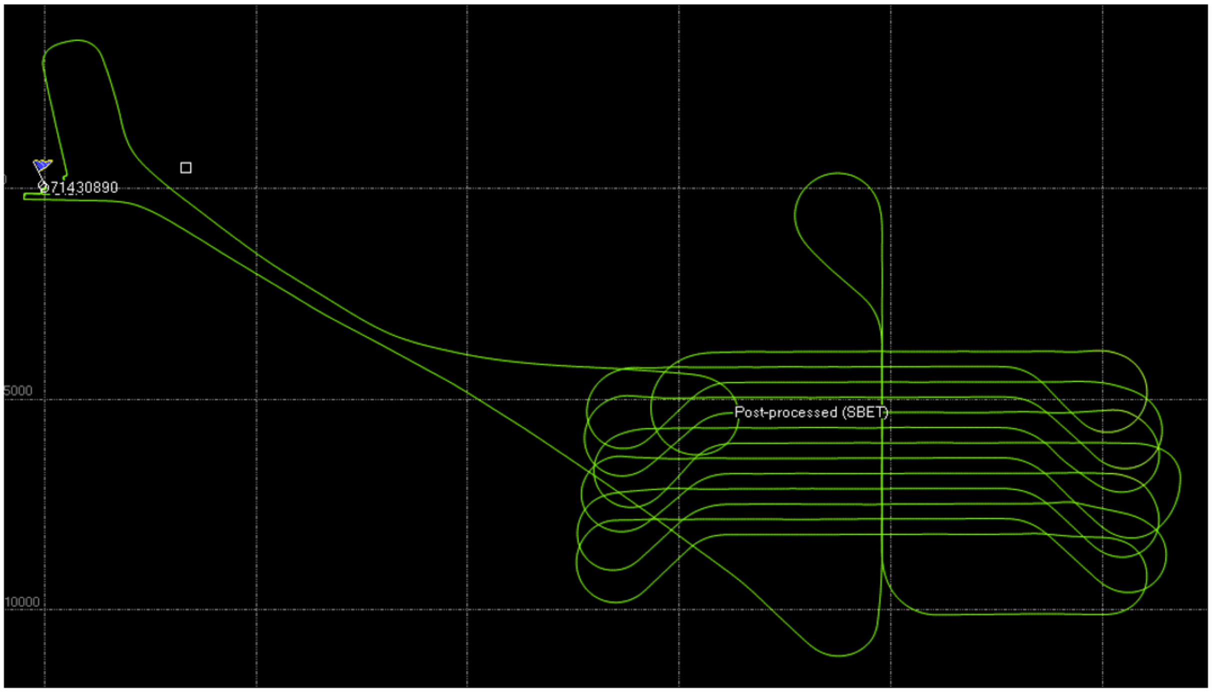
Upon receipt in Rochester, the data is immediately backed up and post-processing begins. Applanix POSPac™ software is utilized to post process the GPS/IMU data utilizing the SmartBase™ (IN-fusion). The SmartBase™ technology uses a centralized filter approach to combine the GPS receiver's raw observables (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 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 baselines 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 final trajectory has been generated, it is applied to the imagery based on 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 and serve as the initial exterior orientation (EO) values.

Applying Trajectory Information

The next step in the production of EagleView's imagery data is the application of the post-processed trajectory data with the 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 measurements and calculations.



Post-processed SBET

Concurrent with the GPS/INS processing, the imagery in RAW format is "developed" to uncompressed TIFF format. During the capture process, EagleView'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. 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. EagleView uses both automated software it has created (proprietary) and human examination when considering whether to reject an image or pass it for production. EagleView's Image Processing Department checks for any of dozens of possible defects while assessing the quality of the imagery.

Oblique Frames

EagleView incorporates DEM data into oblique images using a patented process called a Tessellated Ground Plane (TGP). 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.

Equipment (Sensor data, Mount Orientations, Camera Calibration Reports), Software data (Applanix logs), and NGS data sheets, available upon request.

Orthophotography Production (AccuPlus)

EagleView's AccuPlus certified orthomosaic is a high accuracy orthomosaic generated from the vertical imagery captured by EagleView's Pentaview Capture System. The imagery is auto correlated, surveyed ground control points are measured, and a bundle adjustment performed to ensure the high level of absolute accuracy. The triangulated frames are then orthorectified to a terrain surface either derived from LiDAR, existing Digital Elevation Models (DEM), and/or based on an automated surface extraction directly from the imagery.

The resulting ortho frames are then mosaicked using an automated seamline generating algorithm followed by a manual correction process. Bridge decks and elevated roadways are corrected to be positioned properly; any instances of severe building lean are also corrected to ensure visibility of ground level transportation features. The photogrammetric mapping control utilized is adequate to support the identified accuracy specifications. This report documents the procedures and accuracies, aircraft positing systems and aerial triangulation statistics of the photogrammetric mapping project. The orthophotography is produced to meet the contracted horizontal accuracy specifications and are reported at the 95% confidence level, as specified in the ***ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014).***

Fully Analytical Aerial Triangulation

The digital AGPS/INS aerial photography is processed with MATCH-AT Automatic Aerial Triangulation software to constrain the digital aerial imagery to the Applanix POSPAC software computed X, Y, Z, omega, phi, and kappa photo center parameters and the photogrammetric mapping survey control points. Bundle adjustments consisting of APGS/INS controlled photo center exposures are constrained to ground control points to compute the following values:

1. RMS automatic points in photo
2. RMS control and manual points in photo
3. RMS control points with default standard deviation set
4. RMS IMU observations
5. RMS GNSS observations
6. Average (weighted) sigma naught

GCP Residual Values from Final AT Results

Excerpts from MATCH-AT Processing Report.

AT Block A1:

Accuracy

Sigma naught [micron]	0.8030

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1074	0.1080	0.1111	0.1886

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
1.4179	1.4020	1.4875

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0497	0.0482	0.2859	0.2942

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE20_CHECKPOINT_LEE035A**	3	0.0547	0.0659	-0.0215	0.0883	
2	**FLLEE20_CHECKPOINT_LEE036A**	6	-0.0463	0.0155	-0.0990	0.1104	
3	**FLLEE20_LEE035**	3	-0.0249	-0.1367	0.0017	0.1390	
4	**FLLEE20_LEE036**	7	0.0165	0.0554	0.1189	0.1322	
	Maximum		0.0547	-0.1367	0.1189		
	Mean		0.0000	0.0000	0.0000		
	Sigma		0.0449	0.0937	0.0902		
	RMSE(x,y,z)		0.0389	0.0812	0.0781		
	RMSEr		0.0900	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.1557	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.1531	RMSEz * 1.9600			

AT Block A2:

No GCPs due to AT block layout with respect to waterways.

Accuracy

Sigma naught [micron]	0.8320

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1033	0.1043	0.0515	0.1556

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
1.3895	1.3680	1.2485

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0423	0.0406	0.2472	0.2540

AT Block A3:

No GCPs due to AT block layout with respect to waterways.

Accuracy

Sigma naught [micron]	0.9471

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1183	0.1194	0.0644	0.1801

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
1.8845	1.9276	2.7157

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.1149	0.1058	0.5111	0.5345

AT Block A4:

No GCPs due to AT block layout with respect to waterways.

Accuracy

Sigma naught [micron]	1.0876

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1358	0.1369	0.0775	0.2078

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
2.0900	2.0196	2.8167

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.1011	0.1043	0.4678	0.4898

AT Block A5:

No GCPs due to AT block layout with respect to waterways.

Accuracy

Sigma naught [micron]	0.7960

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1000	0.1012	0.0612	0.1549

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
1.9188	1.7825	3.0165

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.1278	0.1270	0.8026	0.8225

AT Block A6:

Accuracy

Sigma naught [micron]	0.9965

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1308	0.1300	0.1127	0.2161

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
2.1293	2.1231	1.9573

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0510	0.0521	0.3054	0.3140

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE20_CHECKPOINT_LEE032A**	2	0.0335	-0.0573	0.0236	0.0705	
2	**FLLEE20_CHECKPOINT_LEE033A**	6	-0.1023	-0.0233	0.0345	0.1104	
3	**FLLEE20_LEE030**	3	0.0488	0.0545	0.0491	0.0881	
4	**FLLEE20_LEE031**	8	-0.1283	0.0582	-0.1445	0.2018	
5	**FLLEE20_LEE032**	8	0.1441	-0.0335	-0.0182	0.1491	
6	**FLLEE20_LEE033**	5	-0.0184	0.0516	0.0043	0.0550	
7	**FLLEE20_LEE034**	5	0.0226	-0.0503	0.0512	0.0752	
	Maximum		0.1441	0.0582	-0.1445		
	Mean		0.0000	0.0000	-0.0000		
	Sigma		0.0931	0.0524	0.0683		
	RMSE(x,y,z)		0.0862	0.0486	0.0632		
	RMSEr		0.0990	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.1713	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.1240	RMSEz * 1.9600			

AT Block B:

Accuracy

Sigma naught [micron]	1.1245

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1200	0.1221	0.0589	0.1811

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
2.7876	2.6748	1.1001

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0350	0.0344	0.2099	0.2156

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE21_3in_BC_PP074**	3	0.0002	0.0001		0.0003	
2	**FLLEE21_3in_BC_PP075**	3	0.0007	-0.0007		0.0010	
3	**FLLEE21_3in_BC_PP076**	3	0.0000	-0.0032		0.0032	
4	**FLLEE21_3in_BC_PP077**	3	0.0008	0.0003		0.0008	
5	**FLLEE21_3in_BC_PP078**	3	0.0007	0.0022		0.0023	
6	**FLLEE21_3in_BC_PP079**	3	-0.0008	0.0024		0.0025	
7	**FLLEE21_3in_BC_PP080**	6	-0.0012	0.0009		0.0014	
8	**FLLEE21_3in_BC_PP081**	6	0.0017	-0.0054		0.0056	
9	**G20_EVS21_63369**	4	-0.2115	-0.0616	-0.1013	0.2424	
10	**G20_EVS21_63371**	6	-0.1811	0.0429	0.0641	0.1968	
11	**G20_EVS21_63373**	3	0.0968	-0.1102	-0.0410	0.1523	
12	**G20_EVS21_63375**	3	-0.0558	-0.0239	0.0112	0.0617	
13	**G20_EVS21_63377**	5	-0.2055	0.3314	-0.0908	0.4004	
14	**G20_EVS21_63379**	6	-0.1880	0.0150	-0.4258	0.4657	
15	**G20_EVS21_63381**	5	0.1964	0.1005	0.0025	0.2207	
16	**G20_EVS21_63383**	6	0.1091	0.0530	-0.1606	0.2013	
17	**G20_EVS21_63386**	6	-0.0611	-0.1763	0.2536	0.3148	
18	**G20_EVS21_63388**	6	0.2823	0.0647	0.1696	0.3356	
19	**G20_EVS21_63391**	6	0.1643	-0.2274	-0.0090	0.2807	
20	**G20_EVS21_63409**	6	-0.0842	-0.0328	-0.0008	0.0904	
21	**G20_EVS21_63411**	3	-0.2712	-0.0193	-0.0604	0.2785	
22	**G20_EVS21_63413**	6	0.0558	-0.0317	0.0368	0.0739	
23	**G20_EVS21_63415**	7	0.2023	0.1598	-0.0844	0.2713	
24	**G20_EVS21_63418**	5	0.0444	-0.0877	0.1835	0.2082	
25	**G20_EVS21_63420**	3	0.1247	0.0436	0.0026	0.1321	
26	**G20_EVS21_63422**	6	-0.0861	0.1816	-0.0138	0.2015	
27	**G20_EVS21_63425**	3	-0.0707	0.1810	-0.0304	0.1967	
28	**G20_EVS21_63428**	9	0.0111	-0.0430	0.2343	0.2385	
29	**G20_EVS21_63429**	3	-0.1852	0.0391	-0.0427	0.1940	
30	**G20_EVS22_63531**	5	-0.0559	0.0227	0.4439	0.4479	
31	**G20_EVS22_63533**	5	0.0021	0.1218	-0.0258	0.1245	
32	**G20_EVS22_63534**	4	-0.0729	0.2163	-0.0359	0.2311	
33	**G20_EVS22_63537**	9	0.0715	-0.1778	-0.2792	0.3387	
	Maximum		0.2823	0.3314	0.4439		
	Mean		-0.0111	0.0175	-0.0000		
	Sigma		0.1283	0.1144	0.1714		
	RMSE(x,y,z)		0.0009	0.0025	0.1680		
	RMSEr		0.0027	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.0046	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.3292	RMSEz * 1.9600			

AT Block C:

Accuracy

Sigma naught [micron]	1.2867

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1352	0.1284	0.0678	0.1984

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
4.1047	4.0716	1.8820

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0372	0.0400	0.2188	0.2255

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE21_3in_BC_PP074**	3	-0.0004	-0.0000		0.0004	
2	**FLLEE21_3in_BC_PP075**	3	-0.0014	0.0019		0.0023	
3	**FLLEE21_3in_BC_PP076**	3	-0.0005	0.0044		0.0044	
4	**FLLEE21_3in_BC_PP077**	3	-0.0007	0.0010		0.0012	
5	**FLLEE21_3in_BC_PP078**	3	-0.0008	-0.0010		0.0013	
6	**FLLEE21_3in_BC_PP079**	3	0.0004	-0.0013		0.0014	
7	**FLLEE21_3in_BC_PP080**	6	-0.0003	0.0006		0.0006	
8	**FLLEE21_3in_BC_PP081**	6	-0.0023	0.0070		0.0073	
9	**FLLEE21_3in_CD_PP044**	4	0.0008	0.0010		0.0013	
10	**FLLEE21_3in_CD_PP045**	3	0.0002	-0.0001		0.0002	
11	**FLLEE21_3in_CD_PP046**	3	0.0004	-0.0005		0.0006	
12	**FLLEE21_3in_CD_PP047**	4	0.0004	-0.0008		0.0009	
13	**FLLEE21_3in_CD_PP048**	3	0.0008	-0.0005		0.0009	
14	**FLLEE21_3in_CD_PP049**	5	-0.0018	-0.0011		0.0021	
15	**FLLEE21_3in_CD_PP050**	3	0.0002	-0.0007		0.0007	
16	**FLLEE21_3in_CD_PP051**	3	0.0007	-0.0007		0.0009	
17	**FLLEE21_3in_CD_PP052**	3	0.0003	-0.0012		0.0012	
18	**FLLEE21_3in_CD_PP053**	3	0.0003	-0.0004		0.0005	
19	**FLLEE21_3in_CD_PP054**	3	0.0006	-0.0013		0.0015	
20	**FLLEE21_3in_CD_PP055**	3	0.0009	-0.0017		0.0019	
21	**FLLEE21_3in_CD_PP056**	3	0.0009	-0.0015		0.0017	
22	**FLLEE21_3in_CD_PP057**	4	-0.0001	-0.0013		0.0013	
23	**FLLEE21_3in_CD_PP058**	3	0.0007	-0.0009		0.0011	
24	**FLLEE21_3in_CD_PP059**	3	0.0005	-0.0005		0.0007	
25	**FLLEE21_3in_CD_PP060**	3	-0.0009	-0.0013		0.0016	
26	**FLLEE21_3in_CD_PP061**	3	-0.0005	-0.0007		0.0009	
27	**FLLEE21_3in_CD_PP062**	3	-0.0004	-0.0005		0.0007	
28	**FLLEE21_3in_CD_PP063**	3	0.0009	0.0002		0.0009	
29	**FLLEE21_3in_CD_PP064**	3	0.0011	-0.0006		0.0012	
30	**FLLEE21_3in_CD_PP065**	3	0.0012	-0.0006		0.0014	
31	**FLLEE21_3in_CD_PP066**	5	-0.0001	-0.0012		0.0012	
32	**FLLEE21_3in_CD_PP067**	3	0.0002	0.0006		0.0006	
33	**FLLEE21_3in_CD_PP068**	3	0.0003	-0.0004		0.0005	
34	**FLLEE21_3in_CD_PP069**	3	0.0002	-0.0005		0.0006	
35	**FLLEE21_3in_CD_PP070**	3	-0.0008	-0.0004		0.0009	
36	**G20_EVS21_63430**	2	-0.2592	-0.0831	-0.0584	0.2783	
37	**G20_EVS21_63433**	7	0.2755	-0.0427	0.0400	0.2817	
38	**G20_EVS21_63435**	9	-0.1576	0.0154	-0.1325	0.2065	
39	**G20_EVS22_63459**	4	-0.0486	0.2397	-0.0402	0.2479	
40	**G20_EVS22_63506**	3	0.0221	-0.1460	-0.0260	0.1499	

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
41	**G20_EVS22_63508**	3	0.0843	0.0445	-0.0535	0.1093	
42	**G20_EVS22_63511**	6	-0.1518	0.0606	0.0912	0.1872	
43	**G20_EVS22_63514**	3	0.2635	0.0033	-0.1635	0.3101	
44	**G20_EVS22_63515**	5	-0.0220	0.0750	-0.1411	0.1613	
45	**G20_EVS22_63517**	5	-0.1888	0.0769	0.0050	0.2039	
46	**G20_EVS22_63519**	3	0.0812	0.0484	0.0976	0.1359	
47	**G20_EVS22_63521**	3	-0.0141	0.1358	0.0272	0.1393	
48	**G20_EVS22_63522**	3	0.1240	-0.0924	-0.1246	0.1986	
49	**G20_EVS22_63523**	6	-0.0088	-0.1127	0.0462	0.1221	
50	**G20_EVS22_63525**	6	0.0317	0.0842	-0.0525	0.1042	
51	**G20_EVS22_63527**	4	-0.0885	0.1486	0.0315	0.1758	
52	**G20_EVS22_63528**	3	0.2654	0.1956	-0.0181	0.3302	
53	**G20_EVS22_63529**	6	-0.1649	0.1133	0.0875	0.2183	
54	**G20_EVS22_63531**	5	-0.2129	0.1062	0.3841	0.4518	
	Maximum		0.2755	0.2397	0.3841		
	Mean		-0.0031	0.0160	-0.0000		
	Sigma		0.0952	0.0651	0.1224		
	RMSE(x,y,z)		0.0008	0.0017	0.1192		
	RMSEr		0.0018	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.0032	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.2336	RMSEz * 1.9600			

AT Block D:

Accuracy

Sigma naught [micron]	1.6712

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1755	0.1676	0.0824	0.2563

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
5.3177	5.2829	2.4428

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0496	0.0524	0.2876	0.2965

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE21_3in_CD_PP044**	4	-0.0432	-0.0150		0.0457	
2	**FLLEE21_3in_CD_PP045**	3	-0.0131	0.0331		0.0355	
3	**FLLEE21_3in_CD_PP046**	3	-0.0231	0.0513		0.0563	
4	**FLLEE21_3in_CD_PP047**	4	-0.0180	0.0638		0.0663	
5	**FLLEE21_3in_CD_PP048**	3	-0.0319	0.0567		0.0651	
6	**FLLEE21_3in_CD_PP049**	5	0.0645	0.0768		0.1003	
7	**FLLEE21_3in_CD_PP050**	3	0.0007	0.0669		0.0669	
8	**FLLEE21_3in_CD_PP051**	3	-0.0321	0.0579		0.0662	
9	**FLLEE21_3in_CD_PP052**	3	-0.0082	0.0862		0.0866	
10	**FLLEE21_3in_CD_PP053**	3	-0.0142	0.0560		0.0578	
11	**FLLEE21_3in_CD_PP054**	3	-0.0302	0.0898		0.0947	
12	**FLLEE21_3in_CD_PP055**	3	-0.0566	0.1104		0.1240	
13	**FLLEE21_3in_CD_PP056**	3	-0.0387	0.1009		0.1080	
14	**FLLEE21_3in_CD_PP057**	4	0.0083	0.0937		0.0941	
15	**FLLEE21_3in_CD_PP058**	3	-0.0349	0.0743		0.0821	
16	**FLLEE21_3in_CD_PP059**	3	-0.0159	0.0626		0.0646	
17	**FLLEE21_3in_CD_PP060**	3	0.0485	0.0976		0.1090	
18	**FLLEE21_3in_CD_PP061**	3	0.0326	0.0732		0.0801	
19	**FLLEE21_3in_CD_PP062**	3	0.1035	0.1412		0.1750	
20	**FLLEE21_3in_CD_PP063**	3	-0.0624	0.0037		0.0625	
21	**FLLEE21_3in_CD_PP064**	3	-0.0500	0.0532		0.0730	
22	**FLLEE21_3in_CD_PP065**	3	-0.0556	0.0558		0.0788	
23	**FLLEE21_3in_CD_PP066**	5	0.0033	0.0733		0.0733	
24	**FLLEE21_3in_CD_PP067**	3	-0.0218	0.0039		0.0221	
25	**FLLEE21_3in_CD_PP068**	3	-0.0123	0.0476		0.0492	
26	**FLLEE21_3in_CD_PP069**	3	-0.0073	0.0567		0.0572	
27	**FLLEE21_3in_CD_PP070**	3	0.0536	0.0633		0.0829	
28	**FLLEE21_3in_DE_PP001**	3	-0.0315	0.0473		0.0568	
29	**FLLEE21_3in_DE_PP002**	6	-0.0105	-0.0083		0.0134	
30	**FLLEE21_3in_DE_PP003**	6	0.0384	-0.0142		0.0409	
31	**FLLEE21_3in_DE_PP004**	6	0.0683	0.0073		0.0687	
32	**FLLEE21_3in_DE_PP005**	3	-0.0086	-0.0336		0.0347	
33	**FLLEE21_3in_DE_PP006**	3	-0.0339	-0.0445		0.0559	
34	**FLLEE21_3in_DE_PP007**	3	-0.0201	-0.0601		0.0634	
35	**FLLEE21_3in_DE_PP008**	6	-0.0303	-0.0471		0.0560	
36	**FLLEE21_3in_DE_PP009**	5	-0.0387	-0.0949		0.1025	
37	**FLLEE21_3in_DE_PP010**	2	0.2341	-0.1644		0.2861	
38	**FLLEE21_3in_DE_PP011**	6	0.0263	-0.0221		0.0343	
39	**FLLEE21_3in_DE_PP012**	6	-0.0060	-0.0536		0.0539	
40	**FLLEE21_3in_DE_PP013**	4	0.1690	-0.0490		0.1760	

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
41	**FLLEE21_3in_DE_PP014**	6	-0.0681	-0.0004		0.0681	
42	**FLLEE21_3in_DE_PP015**	6	-0.0392	-0.1013		0.1086	
43	**FLLEE21_3in_DE_PP016**	6	-0.0351	-0.0298		0.0460	
44	**FLLEE21_3in_DE_PP017**	6	-0.0144	-0.0619		0.0635	
45	**FLLEE21_3in_DE_PP018**	6	-0.0070	-0.0015		0.0071	
46	**FLLEE21_3in_DE_PP019**	6	-0.1066	-0.0414		0.1143	
47	**FLLEE21_3in_DE_PP020**	6	-0.0259	-0.0523		0.0584	
48	**FLLEE21_3in_DE_PP021**	5	0.0017	0.0932		0.0932	
49	**FLLEE21_3in_DE_PP022**	6	0.0278	0.1060		0.1096	
50	**FLLEE21_3in_DE_PP023**	7	-0.0032	-0.0022		0.0039	
51	**FLLEE21_3in_DE_PP024**	6	0.0007	-0.0071		0.0072	
52	**FLLEE21_3in_DE_PP025**	6	0.0258	-0.0181		0.0315	
53	**FLLEE21_3in_DE_PP026**	6	0.0284	-0.0164		0.0328	
54	**FLLEE21_3in_DE_PP027**	6	0.0174	-0.0782		0.0801	
55	**FLLEE21_3in_DE_PP028**	4	-0.0511	-0.1213		0.1316	
56	**FLLEE21_3in_DE_PP029**	6	-0.0345	-0.1167		0.1217	
57	**FLLEE21_3in_DE_PP030**	6	-0.0369	-0.0614		0.0716	
58	**FLLEE21_3in_DE_PP031**	6	0.0088	-0.1099		0.1103	
59	**FLLEE21_3in_DE_PP032**	6	0.0041	-0.0894		0.0895	
60	**FLLEE21_3in_DE_PP033**	6	-0.0080	-0.0710		0.0715	
61	**FLLEE21_3in_DE_PP034**	7	-0.0362	-0.0682		0.0772	
62	**FLLEE21_3in_DE_PP035**	6	-0.0797	0.0265		0.0839	
63	**FLLEE21_3in_DE_PP036**	4	-0.0512	-0.0010		0.0512	
64	**FLLEE21_3in_DE_PP037**	6	-0.0345	0.0720		0.0799	
65	**FLLEE21_3in_DE_PP038**	5	-0.0577	0.0036		0.0578	
66	**G20_EVS21_63430**	2	-0.0715	0.1383	-0.0904	0.1800	
67	**G20_EVS21_63433**	7	0.2123	-0.0132	-0.1004	0.2352	
68	**G20_EVS21_63435**	9	0.1483	-0.1503	0.2332	0.3146	
69	**G20_EVS21_63436**	6	0.0014	0.0308	0.2054	0.2077	
70	**G20_EVS21_63437**	2	0.0221	0.0633	-0.0072	0.0674	
71	**G20_EVS21_63439**	6	0.0643	-0.2462	0.2215	0.3374	
72	**G20_EVS21_63441**	6	-0.4368	0.1003	0.0413	0.4500	
73	**G20_EVS22_63459**	5	0.3303	0.1681	-0.2940	0.4731	
74	**G20_EVS22_63461**	5	0.0476	0.0302	0.1205	0.1330	
75	**G20_EVS22_63463**	9	-0.2135	0.0039	-0.1961	0.2899	
76	**G20_EVS22_63464**	3	0.2133	0.0796	0.0808	0.2416	
77	**G20_EVS22_63468**	4	-0.0557	-0.1851	0.1801	0.2642	
78	**G20_EVS22_63470**	9	0.1972	-0.0545	-0.0285	0.2065	
79	**G20_EVS22_63472**	6	-0.0385	-0.0787	0.0504	0.1011	
80	**G20_EVS22_63480**	9	0.2416	-0.1745	0.2037	0.3610	

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
81	**G20_EVS22_63482**	6	-0.0976	-0.0106	0.0122	0.0989	
82	**G20_EVS22_63484**	3	-0.1638	-0.2107	-0.1975	0.3321	
83	**G20_EVS22_63486**	5	0.0056	-0.1150	-0.2627	0.2868	
84	**G20_EVS22_63495**	2	-0.0312	0.1491	-0.0894	0.1766	
85	**G20_EVS22_63508**	3	-0.0491	0.1899	-0.1407	0.2414	
86	**G20_EVS22_63511**	6	-0.0190	-0.0444	-0.0525	0.0713	
87	**G20_EVS22_63542**	5	-0.1271	0.0920	-0.0422	0.1625	
88	**G20_EVS22_63544**	6	0.2920	-0.2115	0.1524	0.3914	
	Maximum		-0.4368	-0.2462	-0.2940		
	Mean		0.0000	-0.0000	0.0000		
	Sigma		0.1014	0.0900	0.1585		
	RMSE(x,y,z)		0.0528	0.0687	0.1550		
	RMSEr		0.0867	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.1500	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.3038	RMSEz * 1.9600			

AT Block E:

Accuracy

Sigma naught [micron]	1.4204

Mean standard deviation of translations

X [user]	Y [user]	Z [user]	Total [user]
0.1507	0.1442	0.0795	0.2232

Mean standard deviation of rotations

Omega [deg/1000]	Phi [deg/1000]	Kappa [deg/1000]
4.5578	4.5227	2.4777

Mean standard deviation of terrain points

X [user]	Y [user]	Z [user]	Total [user]
0.0442	0.0461	0.2461	0.2542

Ground control point errors

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
1	**FLLEE21_3in_DE_PP001**	3	0.0315	-0.0585		0.0664	
2	**FLLEE21_3in_DE_PP002**	6	0.0109	-0.0157		0.0191	
3	**FLLEE21_3in_DE_PP003**	6	-0.0376	-0.0095		0.0388	
4	**FLLEE21_3in_DE_PP004**	6	-0.0722	-0.0269		0.0771	
5	**FLLEE21_3in_DE_PP005**	3	0.0096	0.0189		0.0212	
6	**FLLEE21_3in_DE_PP006**	3	0.0360	0.0259		0.0443	
7	**FLLEE21_3in_DE_PP007**	3	0.0251	0.0412		0.0483	
8	**FLLEE21_3in_DE_PP008**	6	0.0356	0.0204		0.0410	
9	**FLLEE21_3in_DE_PP009**	5	0.0521	0.0611		0.0803	
10	**FLLEE21_3in_DE_PP010**	2	-0.0796	0.0738		0.1086	
11	**FLLEE21_3in_DE_PP011**	6	-0.0669	-0.0347		0.0754	
12	**FLLEE21_3in_DE_PP012**	6	0.0442	0.0574		0.0725	
13	**FLLEE21_3in_DE_PP013**	4	-0.1340	0.0577		0.1459	
14	**FLLEE21_3in_DE_PP014**	6	0.0183	-0.0199		0.0270	
15	**FLLEE21_3in_DE_PP015**	6	0.0084	0.0295		0.0307	
16	**FLLEE21_3in_DE_PP016**	6	0.0292	-0.0082		0.0303	
17	**FLLEE21_3in_DE_PP017**	6	-0.0200	-0.0712		0.0740	
18	**FLLEE21_3in_DE_PP018**	6	0.0436	-0.0305		0.0532	
19	**FLLEE21_3in_DE_PP019**	6	0.0850	-0.0846		0.1199	
20	**FLLEE21_3in_DE_PP020**	6	0.0195	0.0224		0.0297	
21	**FLLEE21_3in_DE_PP021**	5	-0.0007	-0.1061		0.1061	
22	**FLLEE21_3in_DE_PP022**	6	-0.0242	-0.1259		0.1282	
23	**FLLEE21_3in_DE_PP023**	7	0.0014	-0.0203		0.0203	
24	**FLLEE21_3in_DE_PP024**	6	-0.0035	-0.0153		0.0157	
25	**FLLEE21_3in_DE_PP025**	6	-0.0283	-0.0044		0.0286	
26	**FLLEE21_3in_DE_PP026**	6	-0.0309	-0.0040		0.0311	
27	**FLLEE21_3in_DE_PP027**	6	-0.0194	0.0607		0.0637	
28	**FLLEE21_3in_DE_PP028**	4	0.0493	0.1009		0.1123	
29	**FLLEE21_3in_DE_PP029**	6	0.0363	0.0949		0.1015	
30	**FLLEE21_3in_DE_PP030**	6	0.0384	0.0369		0.0533	
31	**FLLEE21_3in_DE_PP031**	6	-0.0069	0.0856		0.0859	
32	**FLLEE21_3in_DE_PP032**	6	-0.0003	0.0676		0.0676	
33	**FLLEE21_3in_DE_PP033**	6	0.0125	0.0503		0.0518	
34	**FLLEE21_3in_DE_PP034**	7	0.0424	0.0476		0.0638	
35	**FLLEE21_3in_DE_PP035**	6	0.0860	-0.0493		0.0991	
36	**FLLEE21_3in_DE_PP036**	4	0.0531	-0.0196		0.0565	
37	**FLLEE21_3in_DE_PP037**	6	0.0337	-0.0928		0.0988	
38	**FLLEE21_3in_DE_PP038**	5	0.0569	-0.0220		0.0610	
39	**G20_EVS21_63439**	6	0.1086	-0.0190	0.0689	0.1300	
40	**G20_EVS22_63472**	6	-0.1633	-0.0759	0.1052	0.2086	

#	ID	Fold	X [user]	Y [user]	Z [user]	Total [user]	Remark
41	**G20_EVS22_63473**	6	-0.0761	-0.0035	0.1790	0.1946	
42	**G20_EVS22_63475**	3	0.1180	-0.1136	0.0230	0.1655	
43	**G20_EVS22_63477**	6	0.0828	0.0351	-0.0364	0.0970	
44	**G20_EVS22_63479**	6	-0.0062	0.1220	-0.1510	0.1942	
45	**G20_EVS22_63484**	3	-0.2589	-0.1994	-0.1279	0.3509	
46	**G20_EVS22_63486**	5	0.0494	-0.0257	-0.0094	0.0564	
47	**G20_EVS22_63489**	6	0.0796	0.0903	-0.0739	0.1412	
48	**G20_EVS22_63491**	3	0.1651	0.0377	-0.1118	0.2030	
49	**G20_EVS22_63493**	4	-0.0637	0.1784	-0.0775	0.2047	
50	**G20_EVS22_63495**	2	-0.3034	0.1526	-0.1822	0.3854	
51	**G20_EVS22_63496**	5	0.0394	0.0241	-0.0718	0.0853	
52	**G20_EVS22_63498**	3	-0.0544	0.1226	-0.0823	0.1574	
53	**G20_EVS22_63500**	3	0.0402	-0.1163	0.0839	0.1489	
54	**G20_EVS22_63501**	6	-0.2458	-0.2309	0.2176	0.4013	
55	**G20_EVS22_63503**	3	-0.0557	-0.0967	-0.0074	0.1118	
56	**G20_EVS22_63504**	7	0.0962	-0.0453	0.4045	0.4183	
57	**G20_EVS22_63540**	3	0.1497	0.0168	-0.1581	0.2183	
58	**G20_EVS22_63542**	5	-0.0358	0.0135	0.0074	0.0390	
	Maximum		-0.3034	-0.2309	0.4045		
	Mean		-0.0000	0.0000	-0.0000		
	Sigma		0.0886	0.0789	0.1453		
	RMSE(x,y,z)		0.0459	0.0563	0.1416		
	RMSEr		0.0726	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
	ACCr (at 95% Confidence Level)		0.1257	RMSEr * 1.7308			
	ACCz (at 95% Confidence Level)		0.2776	RMSEz * 1.9600			

Production of Orthomosaics

Automatic aerial triangulation (AAT) was performed on all imagery for use in the production of ortho mosaics. The AAT process makes use of the directly observed exterior orientation (EO) of each exposure, i.e. the position and orientation of each exposure derived from the GPS and INS data in conjunction with ground control points.

EagleView used Inpho's Match-AT software for the final bundle adjustment. EagleView reviewed all residuals between control points and tie points and compared the calculated coordinates of any available check points' values to actual control. EagleView reviewed a statistical analysis of the error propagation and theoretical accuracy. If any control points were not within range or statistical analysis indicated weak ties between images, new manual tie points were added to increase the strength of the solution.

Control points on the photography were checked against control used to ensure that all available control was observed. An initial post process was performed with all control points "set to check" (an unconstrained adjustment) to verify the internal mathematical solution prior to the introduction of the control point values. Control and tie point residuals from the final bundle adjustment were examined and checked against project specifications. The bundle adjustment was also performed with a portion of the GCPs set as check points to verify the accuracy of the aerial triangulation adjustment. The RMSE error of the calculated point coordinates as compared to the surveyed point coordinates are reported.

Following the aerial triangulation phase, the nadir imagery was passed into the ortho imagery production phase. This includes orthorectification and mosaicking of individual frames to create a single area-wide image which was tiled for delivery.

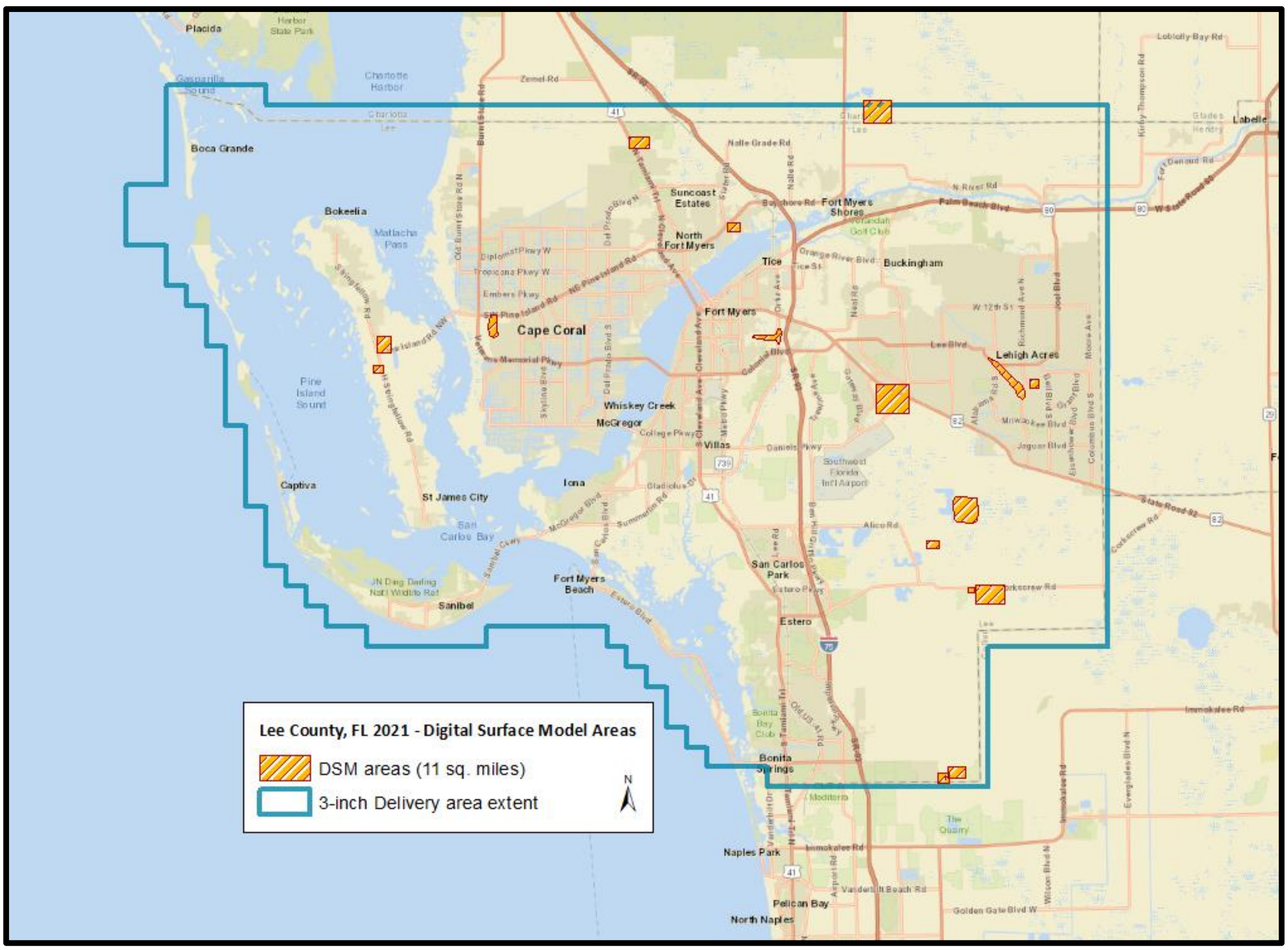
DEM Source for Orthorectification

EagleView utilized the previous 2020 Digital Elevation Model (DEM) created for the 2020 Lee County Orthoimagery Project. This 2020 DEM was developed from the following sources:

- 1/9th arc-second USGS National Elevation Dataset (NED),
- 1/3rd arc-second USGS NED data,
- Update areas by EagleView's DSM process in 2020.

Updated Digital Surface Model

As part of EagleView's quality control process, a Digital Surface Model (DSM) was autocorrelated using the 2021 aerial imagery. The previous 2020 DEM was then visually analyzed for changes and was compared to the autocorrelated surface. Major areas of change were then updated within the composite DSM. These areas are identified in the ***DSM areas*** shown in the map below. Areas of major change are approximately 11 square miles.



Orthorectification

To perform the orthorectification, EagleView utilized the aero-triangulation results, the calibrated camera model parameters, and the digital elevation model (DEM). The orthorectification process was used to remove horizontal displacement caused by terrain height variation, earth curvature, and camera-based distortions. The orthorectification process required a resampling of the imagery; a cubic-convolution method was utilized to perform this resampling. After ortho rectification, each frame containing a control point measurement was checked against the surveyed coordinates to ensure proper rectification.

Color Balancing

Consistent radiometry/photometry is recognized as an important characteristic of an ortho mosaic. EagleView has developed techniques at every step of the process to ensure this consistency in its final ortho mosaics. First, EagleView's Pentaview Sensor System is put through a color calibration prior to deployment to ensure a consistent response from each sensor in EagleView's fleet. Next each exposure is carefully monitored and data pertaining to that exposure stored for use during subsequent processing. Prior to ortho rectification, EagleView 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, EagleView has the option to utilize Inpho's OrthoVista 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 can be performed, as necessary.

Mosaicking

The mosaicking portion of the project consisted of two major steps: radiometric balancing and seamline selection. EagleView utilized both its proprietary software and Inpho’s OrthoVista software package to perform the radiometric balancing. Additionally, local adjustments of brightness values, color, and contrast were performed, as necessary.

Following radiometric balancing, the OrthoVista software package was utilized to generate automatic seamlines between source frames. The automatically generated seamlines were manually edited to eliminate feature misalignment due to seamlines which pass through features located above the DEM. EagleView minimized seamlines through buildings and performed manual corrections where seamlines through buildings are unavoidable.

In addition to editing for geometric considerations, EagleView also edited seam line placement for aesthetic purposes, including elimination of split vehicles and shadows where possible. During the seam editing process, EagleView verified that feature alignment across seamlines is 2 pixels or less.

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 EagleView’s small format camera, building lean is minimized in most cases. To the extent possible utilizing the frames available, EagleView manually corrected 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.

EagleView manually corrected bridges as necessary to ensure proper horizontal placement and to eliminate distortion due to the DEM representing the ground and not the bridge deck. To compensate for this, EagleView used its proprietary image processing software system to ensure ground accuracy where the bridge deck meets the ground and created a deck that averages the elevations of each end of the bridge. This provides an accurate representation of the bridge's true horizontal position while removing distortion. These temporary elevation models are not saved, as they are performed on-the-fly.

In cases where the bridge deck has different elevations at each "end" an average elevation is chosen. In severe cases, the above process may be repeated multiple times along the elevated roadway.

EagleView believes that this process provides the best solution maintaining visual integrity of the bridge deck and roadway, while maximizing spatial accuracy.

Water Bodies

To preserve uniformity of appearance, EagleView utilized the seam editing process to attempt to source inland water bodies from a single frame where possible. In areas where this was not possible, EagleView manually smoothed differences in the color of water bodies and/or applied a single color to said water bodies.

Tiling

Upon completion of the area wide mosaic, EagleView tiled the imagery. Orthorectified GeoTIFF files represent "tiles" cut at even intervals (e.g. 5000 feet X 5000 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 includes tile boundary and filename. Tiles split by the project boundary are completed to their full extent.

Metadata

Project and tile level metadata describing the ortho imagery production process was not contracted as a deliverable.

Abbreviations and Definitions

AAT	Automated Aerial Triangulation
$Accuracy_r$	Horizontal (radial) accuracy at the 95% confidence level, defined by the NSSDA
$Accuracy_z$	Vertical accuracy at the 95% confidence level, defined by the NSSDA
AFB	Air Force Base
AGPS/INS	Airborne Global Positioning System/Inertial Navigation System
Applanix	Trimble company producing software used to post process data
ASFPM	Association of State Floodplain Managers
ASPRS	American Society for Photogrammetry and Remote Sensing
AT	Aerial Triangulation
C6	One of EagleView's proprietary capture systems (not technically an abbreviation)
CAM	Camera
CMAS	Circular Map Accuracy Standard, defined by the NMAS
CORS	Continually Operating Reference Station
CP	Certified Photogrammetrist (ASPRS)
CVA	Consolidated Vertical Accuracy, defined by the NDEP and ASPRS
DEM	Digital Elevation Model (gridded DTM)
DTM	Digital Terrain Model (mass points and breaklines to map the bare earth terrain)
DSM	Digital Surface Model (top reflective surface, includes treetops and rooftops)
E	East, Easting
EO	Exterior Orientation
FAAT	Fully Automated Aerial Triangulation
F.A.C.	Florida Administrative Code
FCDOP	Florida County Digital Orthoimagery Program
FDEM	Florida Division of Emergency Management
FEMA	Federal Emergency Management Agency
FGDC	Federal Geographic Data Committee
FL	Florida
FOV	Field of View
F.S.	Florida Statutes
FVA	Fundamental Vertical Accuracy, defined by the NDEP and ASPRS
GCP	Ground Control Point
GeoTIFF	Georeferenced Tagged Image File Format
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSD	Ground Sample Distance
GZD	Grid Zone Designation
Hrs	Hours
LAS	LiDAR data format as defined by ASPRS
LB	Licensed Business
LiDAR	Light Detection and Ranging
LS	Land Surveyor
H	Height
HARN	High Accuracy Reference Network (NAD 83/2007)
HDOP	Horizontal Dilution of Precision
hz	Horizontal
IMU	Inertial Measurement Unit
In	Inch

INS	Inertial Navigation System
IR	Infrared
LiDAR	Light Detection And Ranging
MATCH-AT	Software package to perform aerial triangulation
mi.	Mile
mm	Millimeter
MSL	Mean sea level
N	North, Northing
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NCG	Nobles Consulting Group
NDEP	National Digital Elevation Program
NE	Northeast
NED	National Elevation Dataset
NGS	National Geodetic Survey
NIR	Near InfraRed
nm	Nanometer
NMAS	National Map Accuracy Standard
NOAA	National Oceanic and Atmospheric Administration
NSSDA	National Standard for Spatial Data Accuracy
NSRS	National Spatial Reference System
NW	Northwest
NY	New York
OPUS	Online Positioning Service
PDOP	Positional Dilution of Precision
PID	Permanent Identifier
POS	Position and Orientation System
POSPac™	Software package produced by Applanix to post process POS data
PS	Photogrammetric Surveyor
PSM	Professional Surveyor and Mapper
QA	Quality Assurance
QC	Quality Control
REF	Reference frame
RGB	Red, Green, and Blue
RMS	Root Mean Square
$RMSE_r$	Horizontal (radial) RMS Error (RMSE) computed from RMSEx and RMSEy
$RMSE_x$	Horizontal RMS Error (RMSE) in the x-dimension (Easting)
$RMSE_y$	Horizontal RMS Error (RMSE) in the y-dimension (Northing)
$RMSE_z$	Vertical RMS Error (RMSE) in the z-dimension (Elevation)
RPY	Roll, Pitch, Yaw
RTK	Real Time Kinematic
rx	Residual in X
ry	Residual in Y
rz	Residual in Z
SBET	Smoothed Best Estimate Trajectory
SE	Southeast
sq.	Square
STD	Standard
Std. Dev	Standard Deviation

SVA	Supplemental Vertical Accuracy, defined by the NDEP and ASPRS
SW	Southwest
TGP	Tessellated Ground Plane
TIFF	Tagged Image File Format
TIN	Triangulated Irregular Network
US	United States
USGS	United States Geological Survey
VDOP	Vertical Dilution of Precision
VMAS	Vertical Map Accuracy Standard, defined by the NMAS
WRT	With Respect To

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