

Camera Calibration Verification
Model: DMC IIe 230 – 23526



For
Midwest Aerial Photography
7535 West Broad Street
Galloway, OH, 43119

Date:
October 3, 2018

Calibration Details

Camera: DMC II 230e - 23526
Manufacturer: DMC
Reference: PAN
Serial Number: 00123108
Date of Calibration: September 15, 2018
Date of Report: October 3, 2018
Number of Pages: 6

This camera system is certified by PixElement and is fully functional within its published specifications and tolerances.

Date of Calibration Certification and Verification - 10/7/2018

Signature



Ben Vander Jagt
Ph.D
CEO/CTO

Calibration Overview

Reference Camera	PAN	
Serial Number	00123108	
Number of rows/columns [pixels]	15552 x 14144	
Pixel Size [μm]	5.600 x 5.600	
Image Size [mm]	87.0912 x 79.2064	
Focal Length [mm]	91.9994 mm	+ /- 0.002 mm
Principal Point [mm]	X= -0.0021 mm, Y= -0.0008 mm	+ /- 0.002 mm

Date of Calibration Flight:

The calibration flight for the DMC was performed on September 15, 2018.

Parameter	Parameter Value
AVG GSD [cm]	5.5
Along-Track Flightlines	4
Number of Cross Track Flight Lines	2
Number of Ground Control Points (GCP) in AT	7
Number of Checkpoints	17
Avg # observations / Control Point	4
Avg Forward-lap [%]	60
Avg Side-lap [%]	40
Average Height Above Ground [m]	855
Average Altitude [m]	1130

Calibration Procedure

The calibration flight for the DMC 230 was performed on September 15, 2018. Imagery was captured with four along-track and two cross-track flightlines, as shown below. A ground control network was utilized for calibration verification. More information on the ground control network can be found in Appendix A. One control point was found to have significant error and was not utilized in the GCP or checkpoint calculations. A total of seven checkpoints were utilized in conjunction with

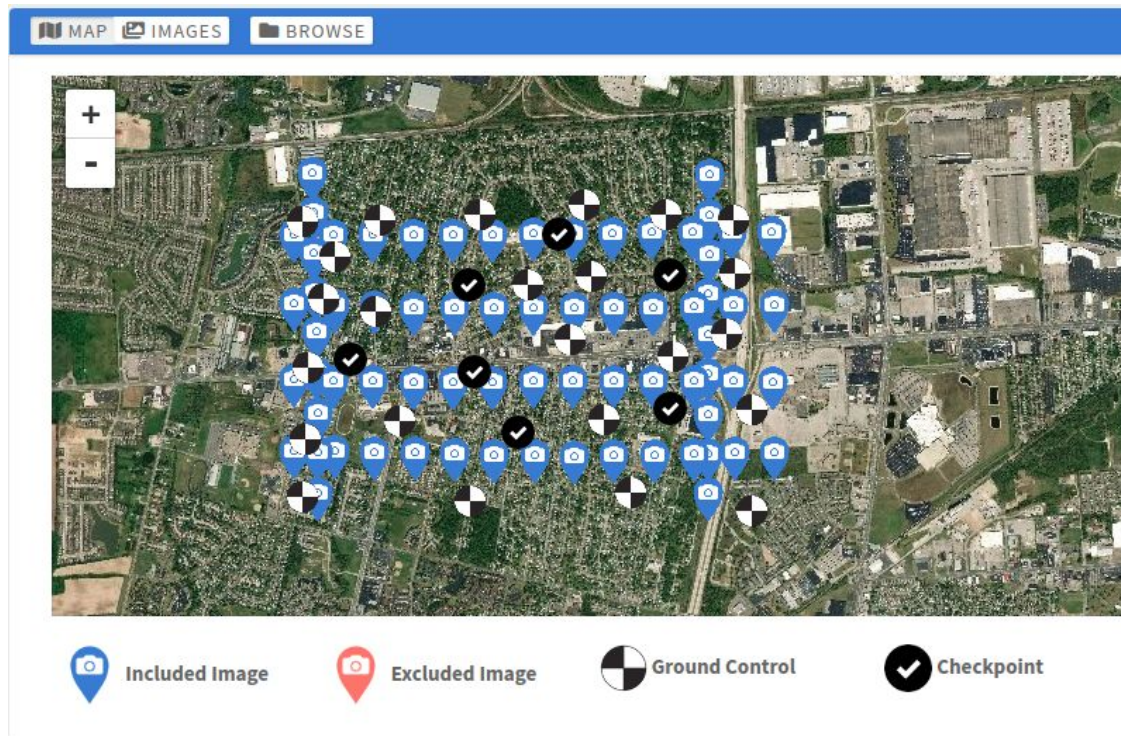


Figure 1: Shown above is the flight lines and distribution of ground control points and checkpoints. See legend for additional details.

The camera constants of previous calibrations were utilized in the verification procedure. GNSS and orientation data were obtained during flight and used as initial values in the Aerial Triangulation (AT) process.

Aerial Triangulation and GCP Details

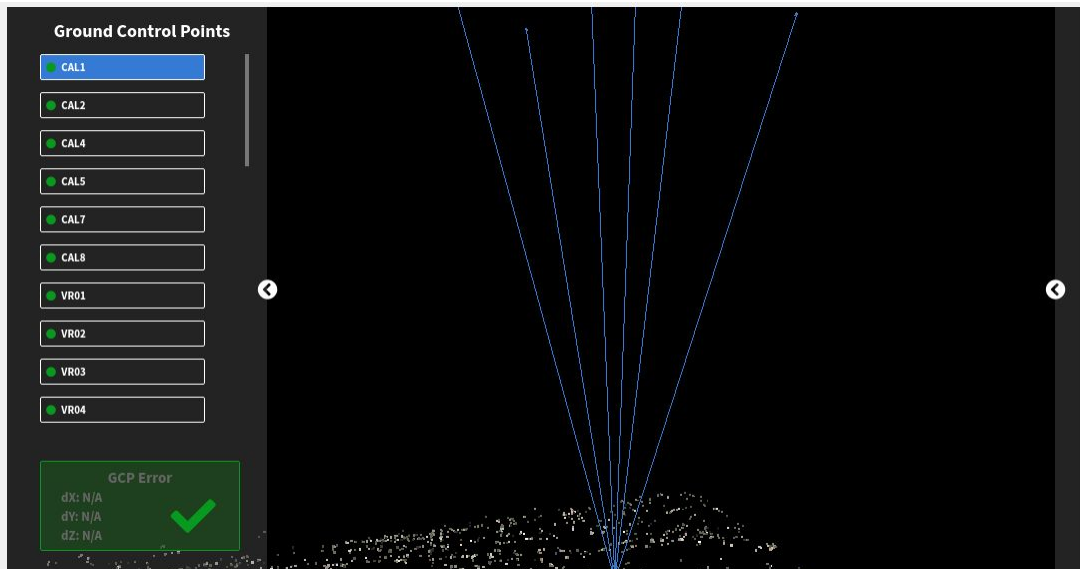


Figure 2: Ground control points were measured in observable images and multi-ray intersection was conducted to calculate the 3D position of the checkpoint. Ground control points were measured manually in the imagery.

Aerial Triangulation Statistics

Parameter	Parameter Adjusted
Focal length	No
Principal Point	No
Radial Distortion	Yes
Tangential Distortion	No
Photo Positions (X,Y,Z)	Yes
Photo Orientations (o, p, k)	Yes
Lever Arm Offset	No
Avg Sidelap	40

Parameter	Parameter Adjusted
Average Reprojection Error (pixels)	0.46
St.Dev of Photo Position [m]	[0.10, 0.12, 0.04]
St.Dev of Photo Orientation [mdeg]	[9.8, 10.3, 11.2]
St. Dev of GCPS [m]	[0.03, 0.02, 0.03]
St. Dev of Checkpoints [m]	[0.04, 0.03, 0.04]
RMS of Photo Positions vs GPS [m]	[0.10, 0.11, 0.79]
RMS of Photo Orientations [mdeg]	[10., 10.4, 11.4]
RMS of GCPs	[0.03, 0.02, 0.04]
RMS of Checkpoints	[0.04 0.03, 0.04]

GCP/Checkpoint Statistics

Parameter	Parameter Adjusted
GCP Horizontal RMSE	[0.03, 0.02]
GCP Vertical RMSE	[0.04]
Checkpoint Horizontal RMSE	[0.04, 0.03]
Checkpoint Vertical RMSE	[0.04]

This aerial triangulation was produced with PixElement Photogrammetry Software.

Appendix A

Standard deviations of horizontal and vertical measurements of the GCP network.

Station	SDHeigh	SDHoriz
CAL1	0.023	0.026
CAL2	0.019	0.024
CAL4	0.019	0.024
CAL5	0.029	0.027
CAL7	0.028	0.028
CAL8	0.041	0.03
VR01	0.021	0.025
VR02	0.022	0.025
VR03	0.023	0.025
VR04	0.023	0.025
VR05	0.019	0.02
VR06	0.02	0.024
VR07	0.019	0.024
VR08	0.026	0.026
VR09	0.022	0.025
VR10	0.02	0.024
VR11	0.021	0.025
VR12	0.02	0.024
VR13	0.02	0.024
VR14	0.02	0.025
VR15	0.02	0.024
VR17	0.021	0.025
VR19	0.019	0.024
VR20	0.021	0.025
VR21	0.023	0.025
VR22	0.026	0.026
VR24	0.019	0.024
VR25	0.018	0.024
VR27	0.023	0.026
VR28	0.035	0.029
VR29	0.025	0.027