



ULTRACAM

Field Calibration Report

Camera: UltraCam Eagle Mark 1
Serial: UC-E-1-50016095-f80
Manufacturer: Vexcel Imaging GmbH, A-8010 Graz,
Austria

Date of Calibration Flight: May-29-2019
Date of Report: Jun-17-2019
Camera Revision: Rev08.00
Version of Report: V01



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Bahia, Brasil 2013

Photo on page 1 courtesy of Hiparc Geotecnologia, Brasil

www.hiparc.com

UltraCam Lp, GSD25 cm, RGB



Calibration Procedure

The purpose of the Field Calibration is a verification of the camera status and calibration and consists of three major steps:

1. Test flight performed by customer
2. Processing of images and aerotriangulation (AT) by Vexcel Imaging GmbH
3. Analysis of AT results by Vexcel Imaging GmbH
4. Provide the new calibration data set and the report

Available Data

Test flight at customer's test site:

- Date of flight: 29/05/2019
- Number of images: 193 (total)
- Flying heights: 1830 m (GSD 7 cm)
3050 m (GSD 15 cm)
- Number of images: 145 (GSD 7 cm)
48 (GSD 15 cm)
- Ground Control Points: 7 (15 used as check points)
- Postprocessed GPS/IMU: available

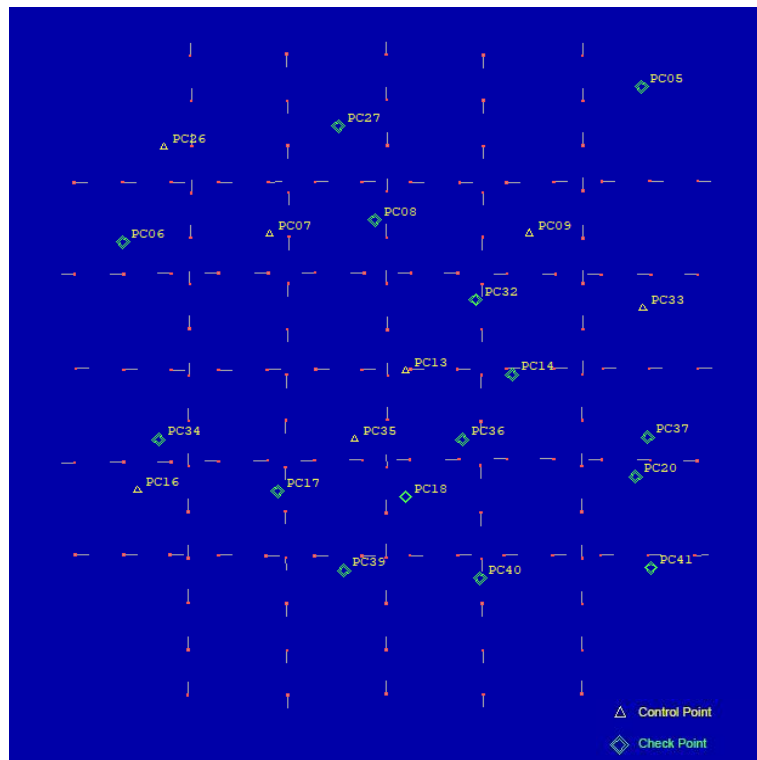
Flight lines look very well done and show good overlap and image quality.

A-priori standard deviations settings

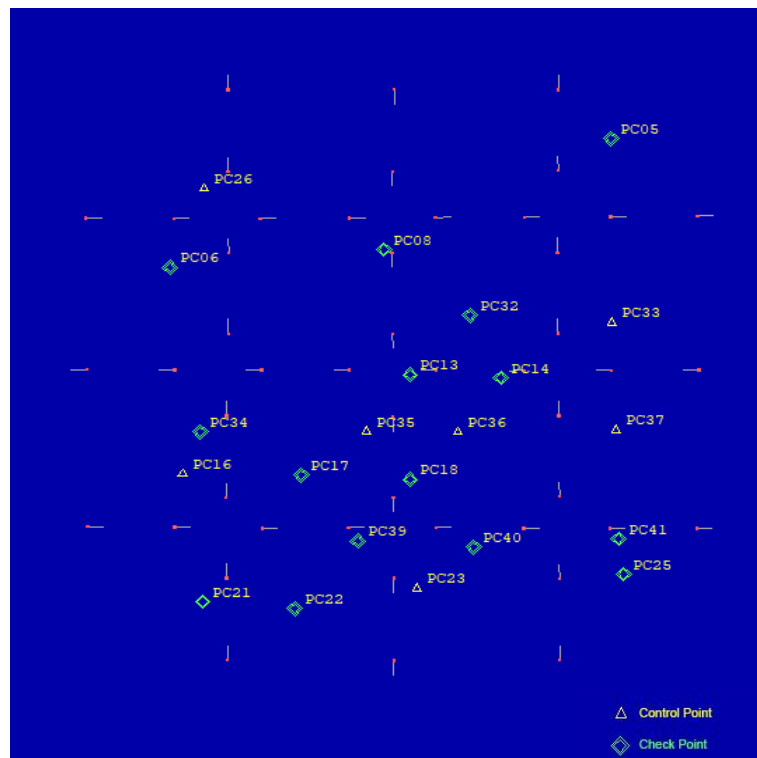
- Image measurements (x,y): 2,3 μ m
- Ground Control Points (x/y/z): 50 mm / 50 mm / 70 mm
- GNSS Position (x,y/ z): 30 mm / 30 mm
- IMU Pose (p,o/ k): 30 mgon / 40 mgon



- Flight at 1830 m (GSD 7 cm):



- Flight at 3050 m (GSD 15 cm):





Results

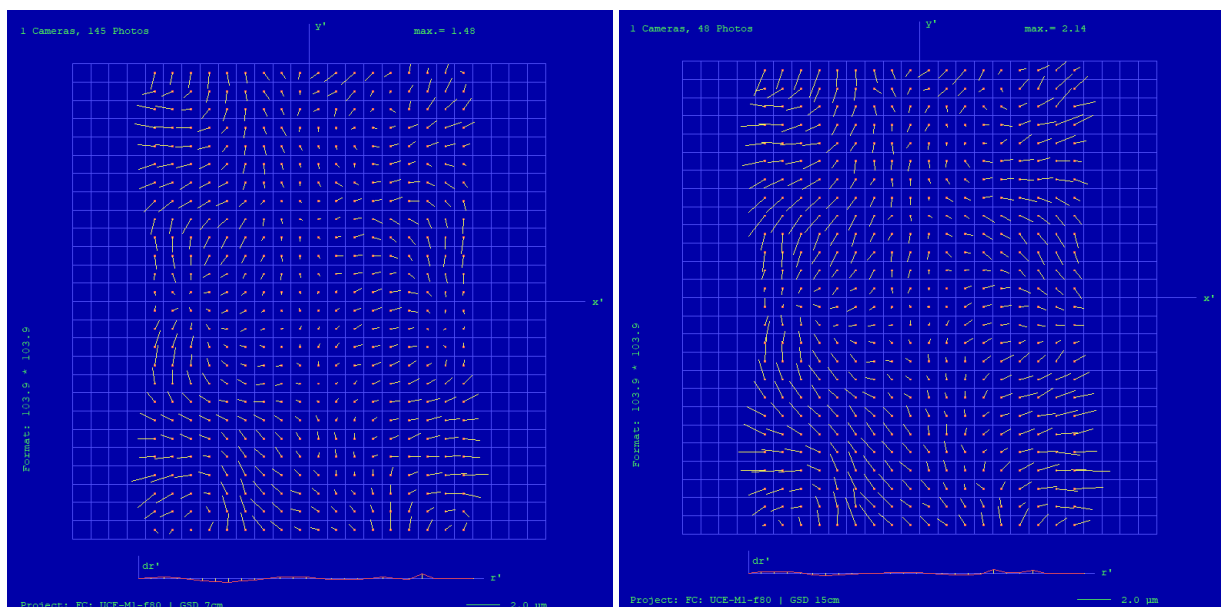
of the Aerial Triangulation with calibration Rev 7.0 (lab calibration), as currently used by the customer.

The data was processed in UltraMap v4.4.7 by Vexcel Imaging GmbH (Process to Lvl02, Automated Tie Point Collection, Ground Control Point measurements, Bundle Adjustment and Analysis).

The results of the Bundle Adjustment are shown in the table below.

	Flight 1830 m (GSD 7 cm)	Flight 3050 m (GSD 15 cm)
Sigma 0	1.29	1.31
Mean photo scale	1:13639	1:28954
RMSE of 15 check points X/Y/Z	39/27/36 mm	31/43/59 mm
RMSE of 7 control points X/Y/Z	38/34/33 mm	37/20/33 mm
Number of used Tiepoints	20546	8165
Refraction Correction	used	used
Earth curvature correction	used	used
Residuals of photo measurements (x', y') in photo space (unit μm):	RMS 1.2, 1.0 MAX 5.2, 6.2	RMS 1.2, 1.1 MAX 6.7, 5.7

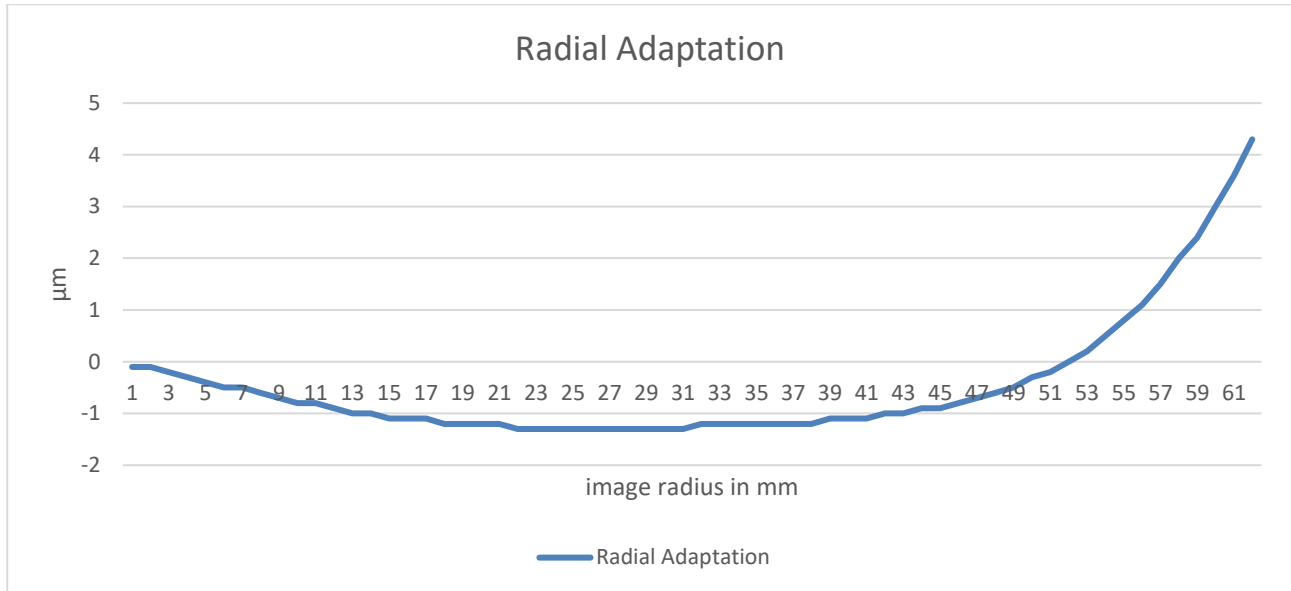
The remaining residuals in the image of the camera are shown in the plots below.





Geometric adjustment

Radial distortion adjustment



Focal Length adjustment

0.0348 mm

Principal Point adjustment

none

Change in focal length is compensated via a scale parameter in the digital calibration dataset. The nominal focal length and principle point as given on pages 9 and 10 are valid for further photogrammetric processing.

Additional local corrections in the image plane are computed from both flight missions at 7 cm GSD and 15 cm GSD. The averaged correction values are applied to the camera calibration data set based on a 1 mm by 1 mm look up table. The magnitude of these corrections in x and y is illustrated in the figure below and shows the correction values at 117 even spaced image positions.



	-32	-24	-16	-8	0	8	16	24	32
48	10.3 -13.6	8.2 -14.2	5.6 -14.2	2.6 -14.8	0.0 -14.9	-2.7 -14.9	-6.6 -15.4	-9.8 -16.4	-12.5 -16.8
40	11.4 -12.3	8.7 -12.5	5.8 -12.4	2.7 -12.9	-0.1 -12.9	-2.8 -13.0	-6.6 -13.5	-10.1 -14.3	-13.3 -14.8
32	11.8 -9.8	9.0 -10.1	5.9 -10.1	2.8 -10.5	-0.1 -10.5	-3.0 -10.7	-6.5 -11.0	-10.1 -11.4	-13.5 -11.7
24	11.9 -6.8	9.1 -7.2	6.0 -7.5	2.9 -7.9	-0.1 -8.0	-3.1 -8.3	-6.4 -8.3	-10.0 -8.2	-13.4 -8.0
16	10.7 -3.4	8.6 -4.0	6.2 -4.6	3.0 -5.1	0.0 -5.0	-3.0 -5.2	-6.6 -5.0	-9.5 -4.7	-12.1 -4.4
8	10.4 -1.5	8.4 -1.9	6.1 -2.2	3.1 -2.7	0.0 -2.6	-3.1 -2.7	-6.5 -2.5	-9.3 -2.2	-11.8 -2.0
0	10.2 0.2	8.2 0.2	5.9 0.2	3.1 0.0	0.0 0.0	-3.1 0.0	-6.3 0.0	-9.0 0.2	-11.6 0.4
-8	10.2 1.9	8.1 2.3	5.9 2.7	3.1 2.7	0.0 2.6	-3.1 2.7	-6.2 2.5	-9.0 2.6	-11.5 2.8
-16	10.2 3.7	8.1 4.4	5.7 5.1	3.0 5.1	0.0 5.0	-3.0 5.2	-6.0 5.0	-8.9 5.1	-11.5 5.2
-24	11.1 6.7	8.7 7.1	6.1 7.5	3.5 7.8	0.3 7.8	-2.9 7.9	-6.1 8.0	-9.2 8.0	-12.2 7.9
-32	11.1 9.6	8.7 9.7	6.0 9.7	3.4 10.2	0.4 10.3	-2.7 10.6	-5.9 10.6	-9.3 10.9	-12.5 11.0
-40	10.8 11.9	8.5 12.0	6.0 11.7	3.4 12.4	0.5 12.7	-2.5 13.2	-5.8 13.0	-9.3 13.5	-12.5 13.6
-48	9.8 13.0	8.1 13.4	5.8 13.2	3.4 14.2	0.6 14.7	-2.2 15.3	-5.5 14.9	-8.9 15.2	-11.8 15.0

Image correction in x and y given in μm at 117 image positions at an 8 mm grid.



Results

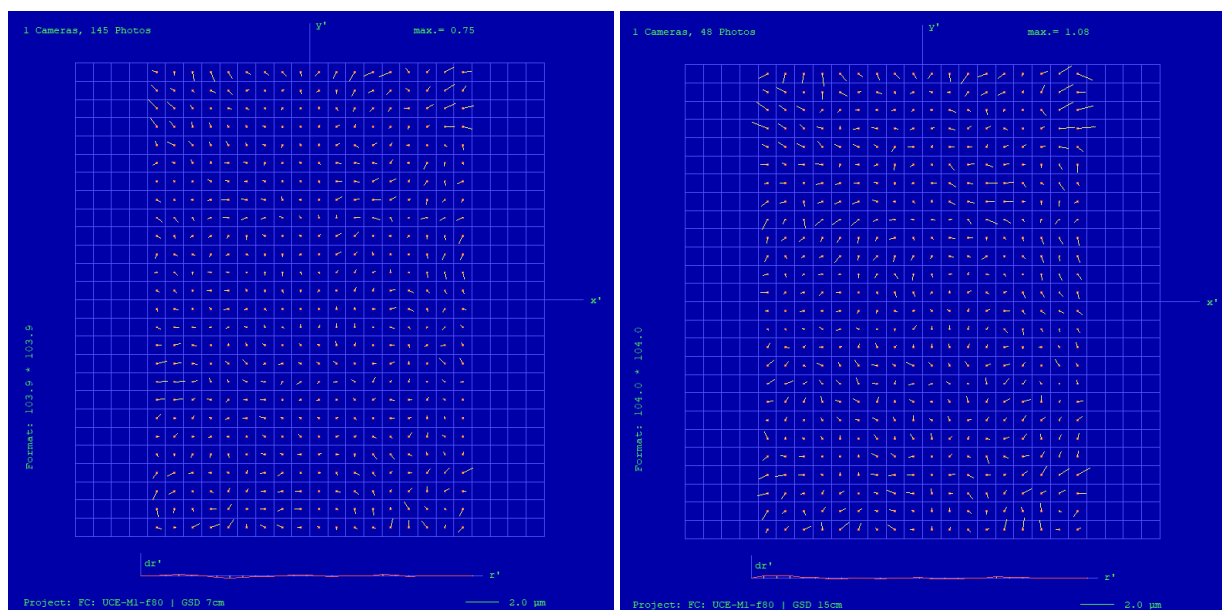
of the Aerial Triangulation with calibration Rev 8.0, this field calibration, which includes the geometric adjustments listed above and will serve as the new calibration for the customer.

The data was processed in UltraMap v4.4.7 by Vexcel Imaging GmbH (Process to Lvl02, Automated Tie Point Collection, Ground Control Point measurements, Bundle Adjustment and Analysis).

The results of the Bundle Adjustment are shown in the table below.

	Flight 1830 m (GSD 7 cm)	Flight 3050 m (GSD 15 cm)
Sigma 0	1.02	1.09
Mean photo scale	1:13634	1:28944
RMSE of 15 check points X/Y/Z	38/18/37 mm	30/41/38 mm
RMSE of 7 control points X/Y/Z	33/25/29 mm	31/28/28mm
Number of used Tiepoints	20564	8033
Refraction Correction	Used	used
Earth curvature correction	Used	used
Residuals of photo measurements (x', y') in photo space:	RMS 1.1, 0.9 MAX 6.3, 6.3	RMS 1.0, 0.9 MAX 5.2, 5.1

The remaining residuals in the image of the camera are shown in the plots below.





ULTRACAM

Geometric Specifications

Camera:	UltraCam Eagle Mark 1
Serial:	UC-E-1-50016095-f80

Panchromatic Camera:	ck = 79.800 mm
Multispectral Camera:	ck = 79.800 mm

PPA Information:	X: 0.000 mm
	Y: 0.000 mm



Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track cross track	68.016 mm 104.052 mm	13080 pixel 20010 pixel
Image Extent		(-34.008, -52.026) mm	(34.008, 52.026) mm
Pixel Size		5.200 μm *5.200 μm	
Focal Length	ck	79.800 mm	± 0.002 mm
Principal Point (Level 2)	X_ppa	0.000 mm	± 0.002 mm
	Y_ppa	0.000 mm	± 0.002 mm
Lens Distortion	Remaining Distortion less than 0.002 mm		

Multispectral Camera

Medium Format Multispectral Output Image (Upscaled to panchromatic image format)

Image Format	long track cross track	68.016 mm 104.052 mm	4360 pixel 6670 pixel
Image Extent		(-34.008, -52.026) mm	(34.008, 52.026) mm
Pixel Size		15.600 μm *15.600 μm	
Focal Length	ck	79.800 mm	± 0.002 mm
Principal Point (Level 2)	X_ppa	0.000 mm	± 0.002 mm
	Y_ppa	0.000 mm	± 0.002 mm
Lens Distortion	Remaining Distortion less than 0.002 mm		



Conclusion

The tables and plots above show acceptable results for the processing with the new camera calibration (Rev 8.0). The calibration was verified with two datasets of the same test area acquired at different altitudes. The remaining distortions in the image are within an acceptable range.

This equipment is operating within specification as defined by Vexcel Imaging GmbH.

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