

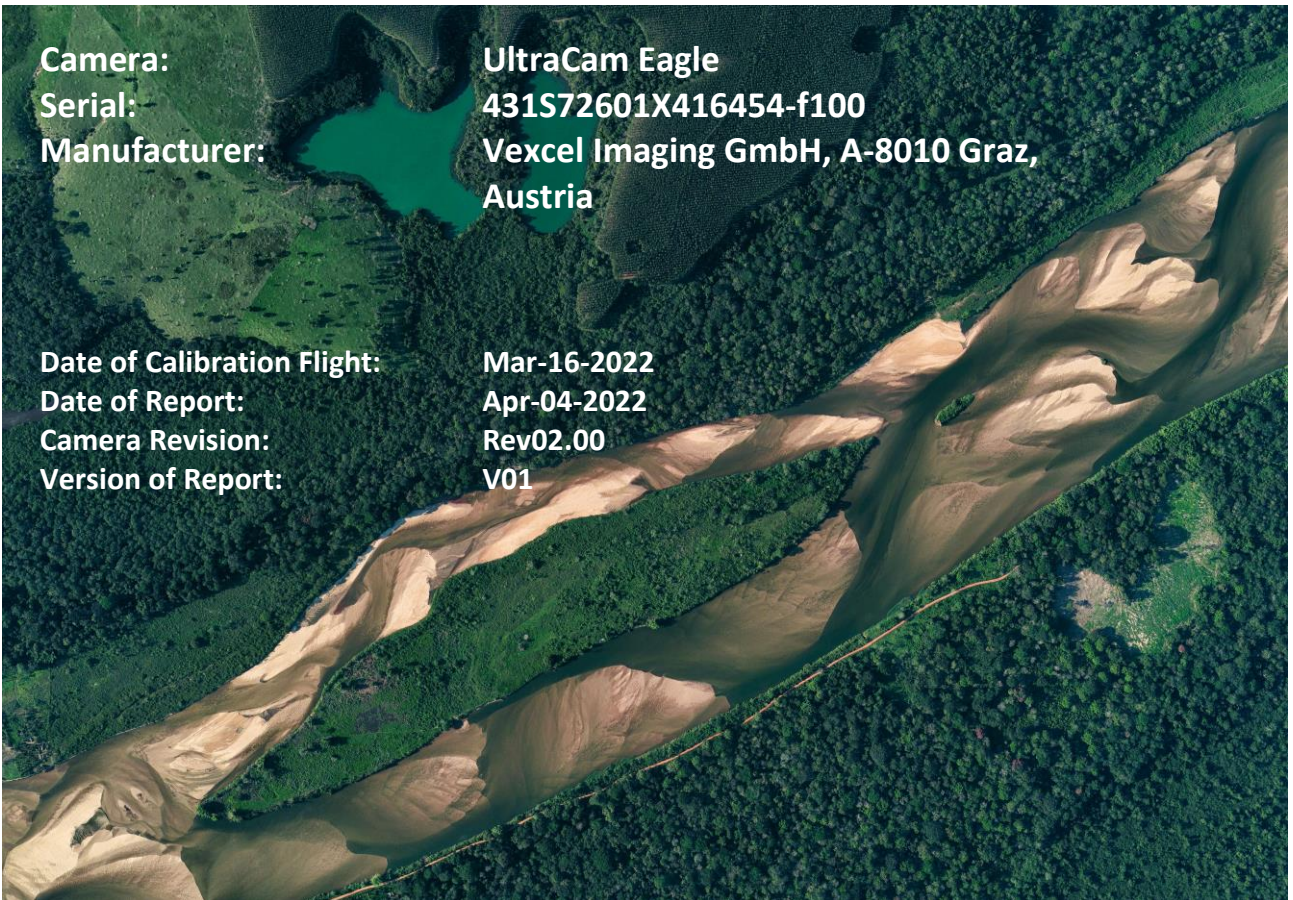


ULTRACAM

Field Calibration Report

Camera: UltraCam Eagle
Serial: 431S72601X416454-f100
Manufacturer: Vexcel Imaging GmbH, A-8010 Graz,
Austria

Date of Calibration Flight: Mar-16-2022
Date of Report: Apr-04-2022
Camera Revision: Rev02.00
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

Available Data

Test flight at customer's test site:

- Date of flight: 16/03/2022
- Number of images: 287 (total)
- Flying heights: 750m (GSD 3cm)
1500m (GSD 6cm)
- Number of images: 227 (GSD 3cm)
60 (GSD 6cm)
- Ground Control Points: 5 (15 were used as check points)
- Postprocessed GPS/IMU: available

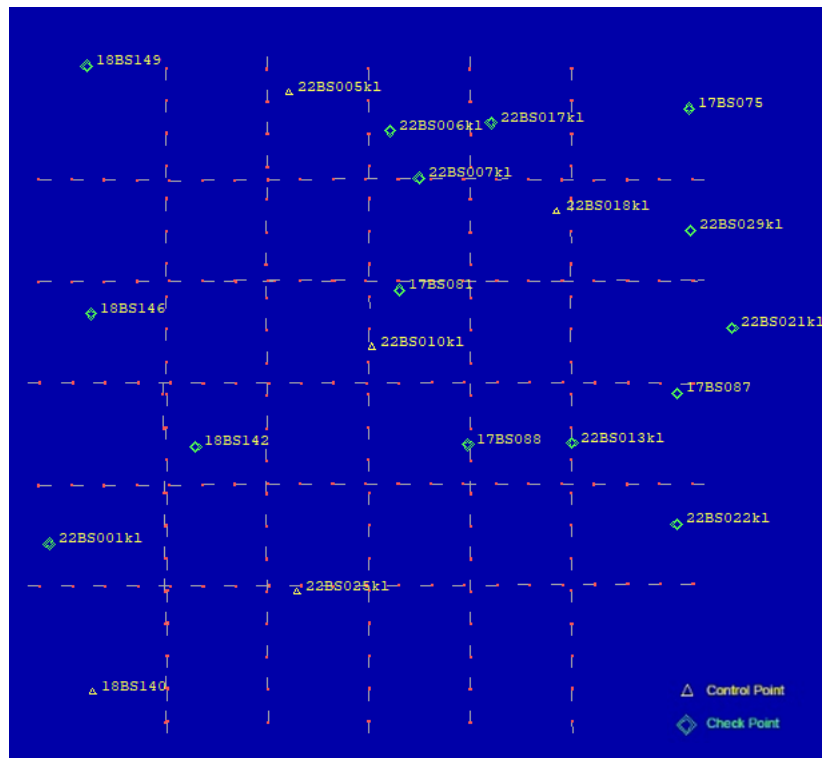
Flight lines look very well done and show good overlap and image quality.

A-priori standard deviations settings

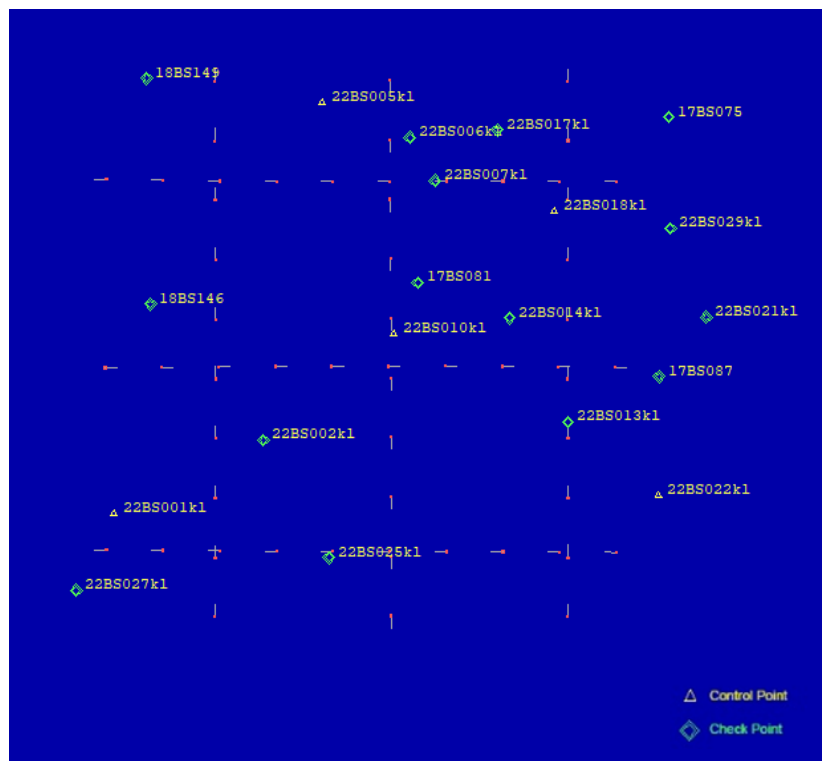
- Image measurements (x,y): 2.0 μ m
- Ground Control Points (x,y/z): 50 mm / 70 mm
- GNSS Position (x,y/ z): 55 mm / 55 mm
- IMU Pose (p,o/ k): 4 mgon / 10 mgon



- Flight at 750m (GSD 3cm):



- Flight at 1500m (GSD 6cm):

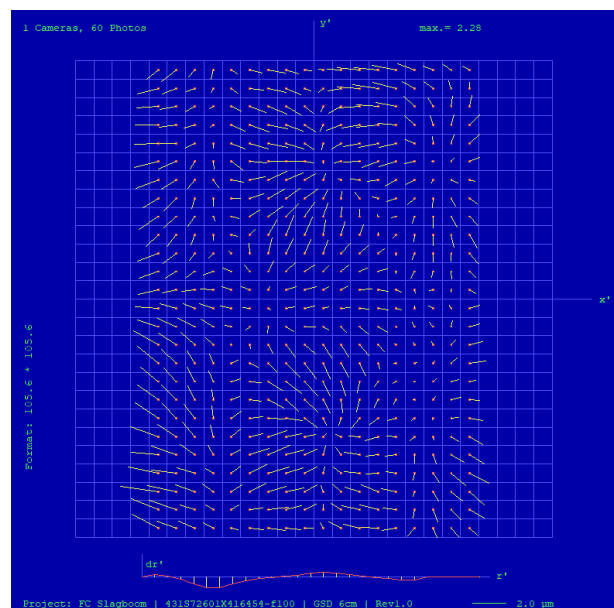




of the Aerial Triangulation with calibration Rev 01.00 (labor calibration), as currently used by the customer.

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

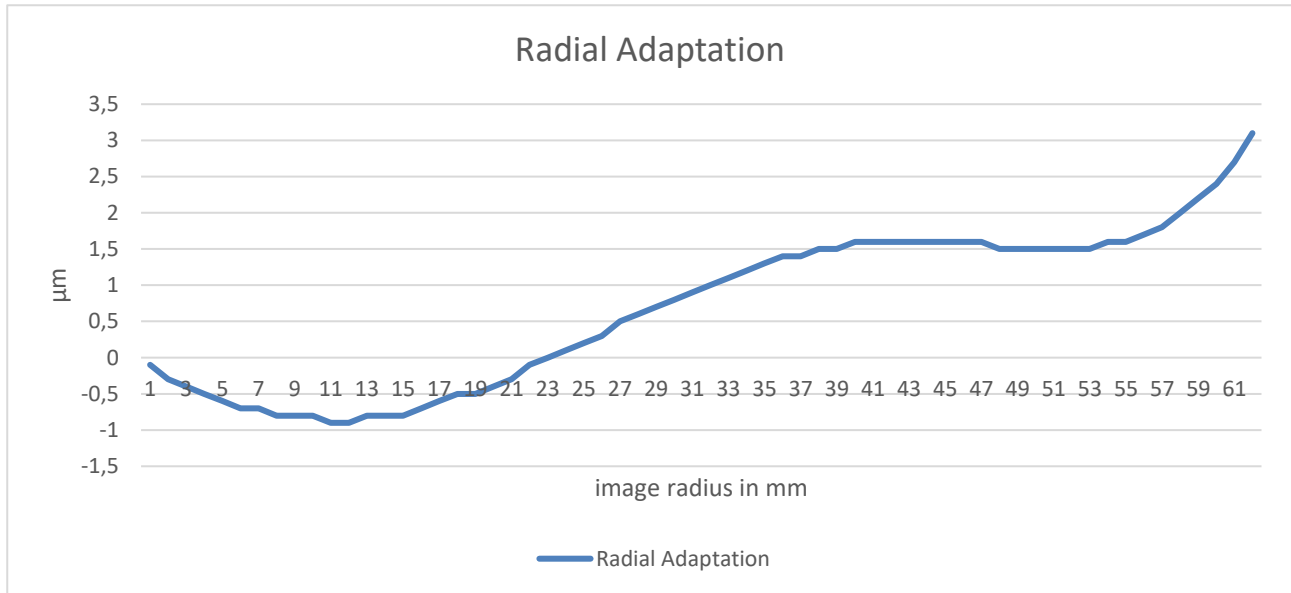
	Flight 750m (GSD 3cm)	Flight 1500m (GSD 6cm)
Sigma 0	1.23	1.2
Mean photo scale	1:7327	1:14809
RMSE of 15 check points X/Y/Z	41/35/34mm	86/61/32mm
RMSE of 5 control points X/Y/Z	21/49/36mm	71/68/20mm
Number of used Tiepoints	34606	8130
Refraction Correction	used	used
Earth curvature correction	used	used
Residuals of photo measurements (x', y') in photo space (unit μm):	RMS 1.2, 0.9 MAX 6.3, 6.1	RMS 1.2, 0.9 MAX 4.9, 5.3





Geometric adjustment

Radial distortion adjustment



Focal length 0.01825mm

Principal Point 0.1/-12.1µm

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 3 cm GSD and 6 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	4.0 -15.9	3.1 -16.1	2.1 -16.0	1.1 -16.0	0.1 -15.9	-0.9 -16.0	-1.9 -16.0	-2.9 -16.1	-3.8 -15.9
40	4.1 -15.1	3.0 -14.9	2.0 -14.8	1.0 -14.7	0.1 -14.7	-0.8 -14.7	-1.8 -14.8	-2.8 -14.9	-3.9 -15.1
32	3.9 -13.9	2.9 -13.8	1.9 -13.8	1.1 -13.9	0.1 -14.0	-0.9 -13.9	-1.8 -13.8	-2.7 -13.8	-3.7 -13.9
24	3.8 -12.8	2.9 -12.9	2.2 -13.2	1.2 -13.5	0.1 -13.7	-1.1 -13.5	-2.0 -13.2	-2.7 -12.9	-3.6 -12.8
16	3.8 -11.9	3.2 -12.2	2.6 -12.6	1.6 -13.0	0.1 -13.2	-1.4 -13.0	-2.4 -12.6	-3.0 -12.2	-3.6 -11.9
8	3.9 -11.0	3.6 -11.2	3.1 -11.6	1.9 -11.9	0.1 -12.1	-1.7 -11.9	-2.9 -11.6	-3.4 -11.2	-3.7 -11.0
0	4.0 -10.1	3.7 -10.1	3.3 -10.1	2.1 -10.1	0.1 -10.1	-1.9 -10.1	-3.1 -10.1	-3.5 -10.1	-3.8 -10.1
-8	3.9 -9.1	3.6 -8.9	3.1 -8.6	1.9 -8.2	0.1 -8.1	-1.7 -8.2	-2.9 -8.6	-3.4 -8.9	-3.7 -9.1
-16	3.8 -8.2	3.2 -8.0	2.6 -7.6	1.6 -7.1	0.1 -6.9	-1.4 -7.1	-2.4 -7.6	-3.0 -8.0	-3.6 -8.2
-24	3.8 -7.3	2.9 -7.2	2.2 -6.9	1.2 -6.6	0.1 -6.5	-1.1 -6.6	-2.0 -6.9	-2.7 -7.2	-3.6 -7.3
-32	3.9 -6.3	2.9 -6.4	1.9 -6.4	1.1 -6.2	0.1 -6.2	-0.9 -6.2	-1.8 -6.4	-2.7 -6.4	-3.7 -6.3
-40	4.1 -5.1	3.0 -5.3	2.0 -5.4	1.0 -5.5	0.1 -5.5	-0.8 -5.5	-1.8 -5.4	-2.8 -5.3	-3.9 -5.1
-48	4.0 -4.3	3.1 -4.1	2.1 -4.1	1.1 -4.2	0.1 -4.2	-0.9 -4.2	-1.9 -4.1	-2.9 -4.1	-3.8 -4.3

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



Results

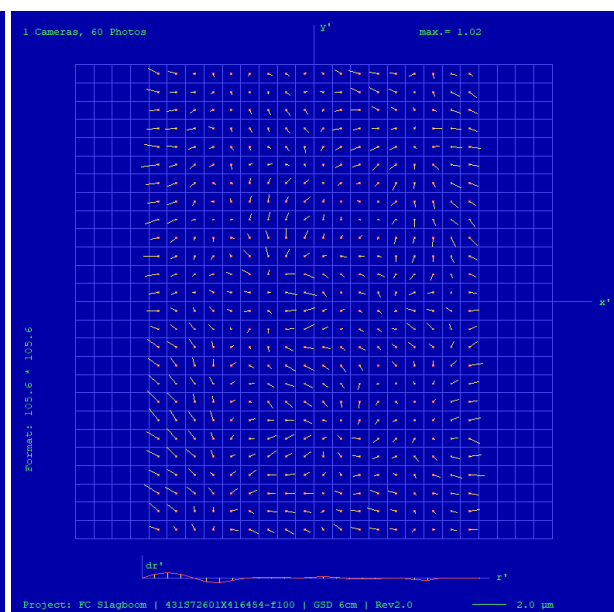
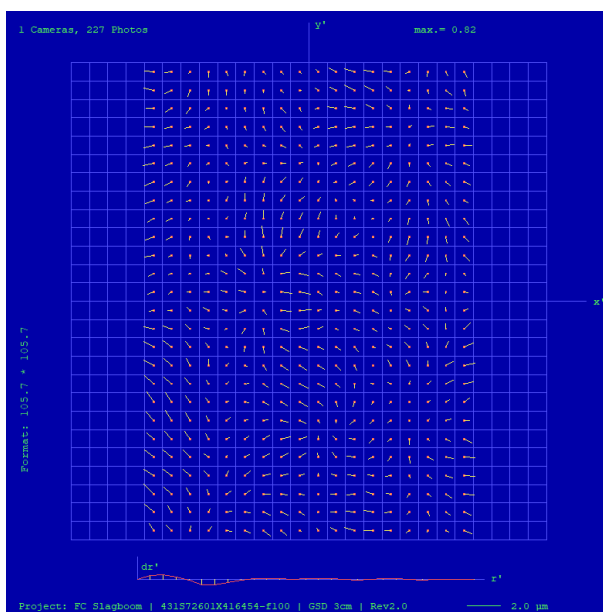
of the Aerial Triangulation with calibration Rev 02.00 (field calibration), which will serve as the new calibration for the customer.

The data was processed in UltraMap v5.5 by Vexcel Imaging GmbH (Process to Lvl02, Automated Tie Point Collection, Bundle Adjustment and Analysis).

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

	Flight 750m (GSD 3cm)	Flight 1500m (GSD 6cm)
Sigma 0	0.91	0.91
Mean photo scale	1:7326	1:14805
RMSE of 15 check points X/Y/Z	22/25/25mm	19/26/17mm
RMSE of 5 control points X/Y/Z	11/22/14mm	16/19/11mm
Number of used Tiepoints	34147	9731
Refraction Correction	used	used
Earth curvature correction	used	used
Residuals of photo measurements (x', y') in photo space:	RMS 0.8, 0.8 MAX 5.0, 4.7	RMS 0.9, 0.7 MAX 4.0, 3.9

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





ULTRACAM

Geometric Specifications

Camera:	UltraCam Eagle
Serial:	431S72601X416454-f100

Panchromatic Camera:	ck = 100.500 mm
Multispectral Camera:	ck = 100.500 mm

PPA Information:	X: -0.160 mm
	Y: 0.000 mm



Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track cross track	68.016mm 105.840mm	17004pixel 26460pixel
Image Extent		(-34.008, -52.920)mm	(34.008, 52.920)mm
Pixel Size		4.000μm*4.000μm	
Focal Length	ck	100.500mm	± 0.002mm
Principal Point (Level 2)	X_ppa	-0.160mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		

Multispectral Camera

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

Image Format	long track cross track	68.016mm 105.840mm	5668pixel 8820pixel
Image Extent		(-34.008, -52.920)mm	(34.008, 52.920)mm
Pixel Size		12.000μm*12.000μm	
Focal Length	ck	100.500mm	± 0.002mm
Principal Point (Level 2)	X_ppa	-0.160mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
Lens Distortion	Remaining Distortion less than 0.002mm		



Conclusion

The tables and plots above show acceptable results for the processing with new the camera calibration. 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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