



# ULTRACAM

## Field Calibration Report

Camera: UltraCam Eagle 4.1  
Serial: 436S72228X114041-f90  
Manufacturer: Vexcel Imaging GmbH, A-8010 Graz,  
Austria

Date of Calibration Flight: Jun-06-2023  
Date of Report: Aug-10-2023  
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](http://www.hiparc.com)

UltraCam Lp, GSD25 cm, RGB



# Calibration Procedure

The purpose of the Field Calibration is a verification of the camera status and its calibration. The process consists of the following four 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 new calibration data set and corresponding report

## Available Data

Test flight at customer's test site:

- Date of flight: 06/06/2023
- Number of images: 302 (total)
- Flying heights: 1200m (GSD 4cm)  
2400m (GSD 8cm)
- Number of images: 230 (GSD 4cm)  
72 (GSD 8cm)
- Ground Control Points: 20 (15 used as check points)
- Postprocessed GPS/IMU: available

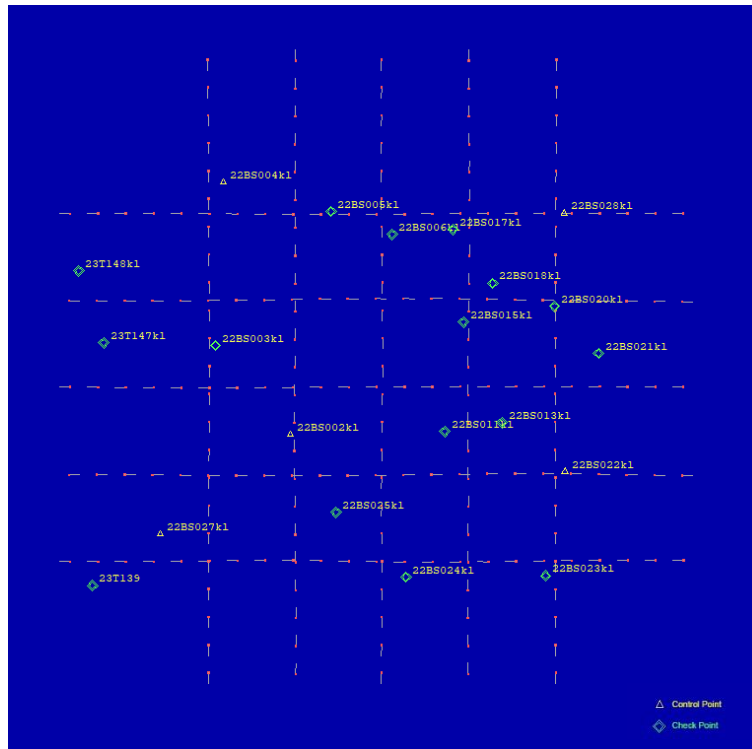
Flight lines look very well done and show good overlap and image quality.

## A-priori standard deviations settings

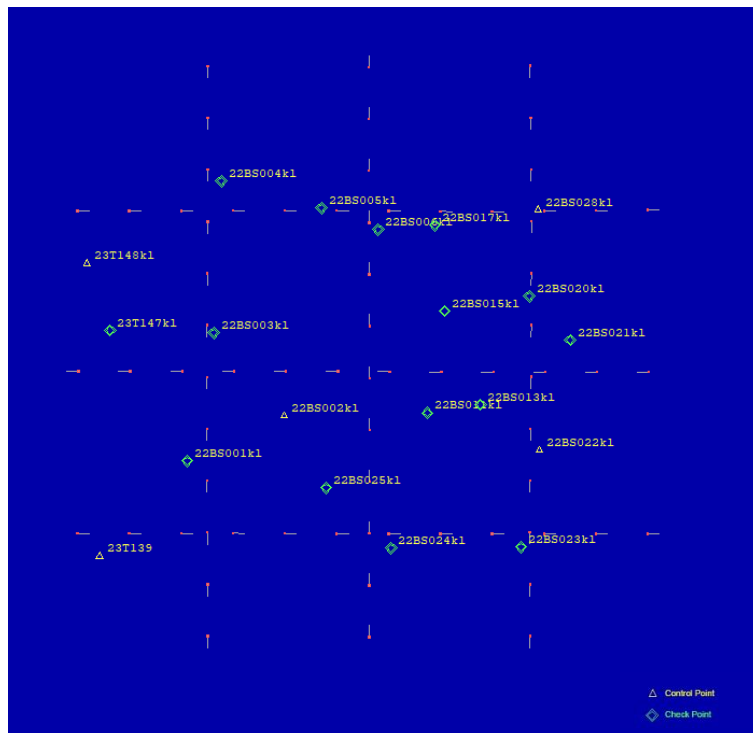
- Image measurements (x/y): 1.9 $\mu$ m
- Ground Control Points (x/y, z): 50mm / 70mm
- GNSS Position (x/y, z): 20mm / 20mm
- IMU Pose (p/o, k): 3mgon / 6mgon



- Flight at 1200m (GSD 4cm):



- Flight at 2400m (GSD 8cm):





## Results

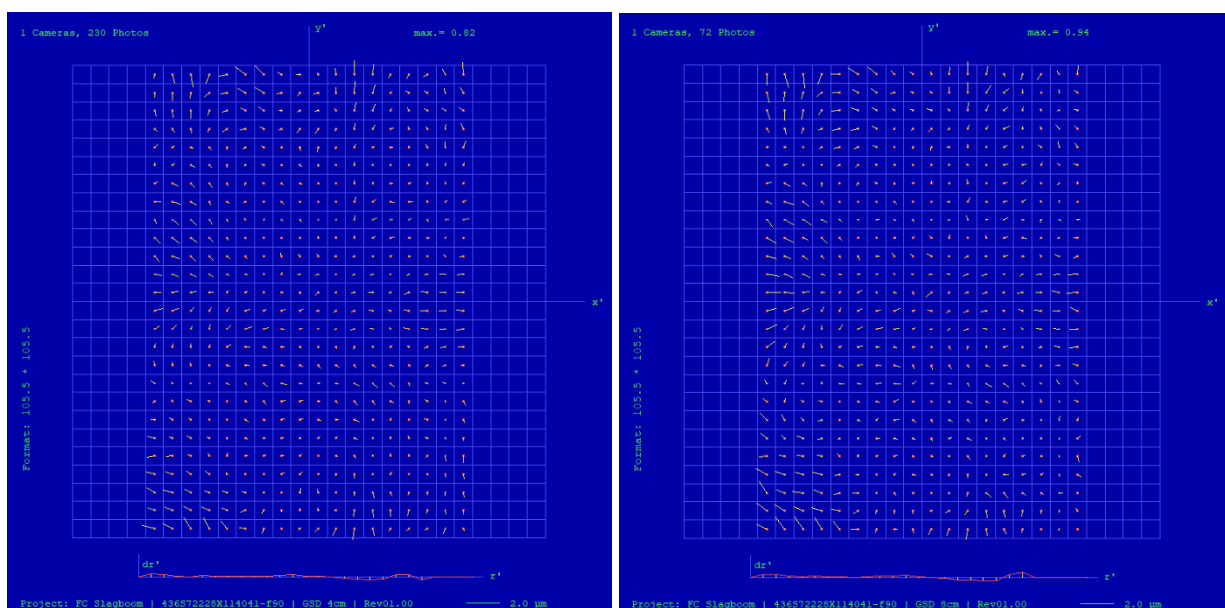
of the Aerial Triangulation with calibration Rev01.00 (lab calibration), as currently used by the customer.

The data was processed in UltraMap v6.0.4 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 1200m (GSD 4cm)	Flight 2400m (GSD 8cm)
<b>Sigma 0</b>	0.82	0.83
<b>Mean photo scale</b>	1:10456	1:21026
<b>RMSE of 15 check points X/Y/Z</b>	24/15/18mm	57/48/33mm
<b>RMSE of 5 control points X/Y/Z</b>	16/18/17mm	76/48/49 mm
<b>Number of used Tiepoints</b>	32930	10855
<b>Refraction Correction</b>	used	used
<b>Earth curvature correction</b>	used	used
<b>Residuals of photo measurements (x', y') in photo space (unit <math>\mu\text{m}</math>):</b>	RMS 0.7, 0.7 MAX 4.2, 3.7	RMS 0.8, 0.7 MAX 3.7, 3.7

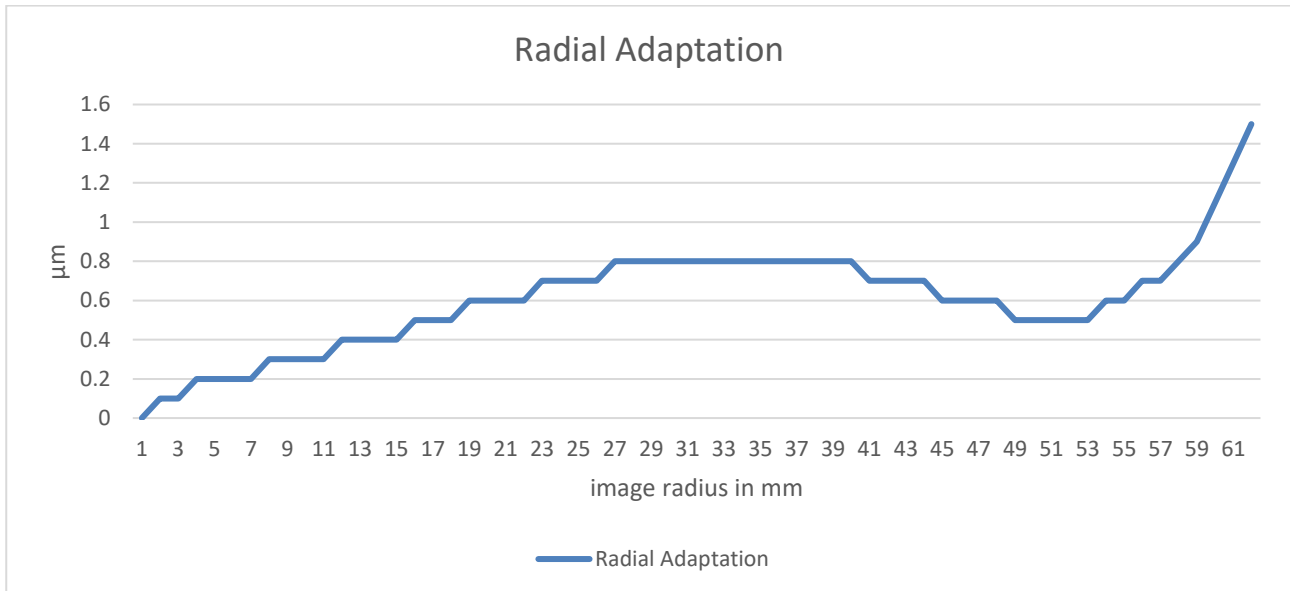
The remaining residuals in the image of the camera are shown in the plots below.





## Geometric adjustment

### Radial distortion adjustment



Focal Length adjustment

0.0021mm

Principal Point adjustment

+5.5µm / -1.7µm

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 4cm GSD and 8cm 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	7.4 -4.6	7.0 -4.8	6.5 -4.8	6.0 -4.8	5.5 -4.7	5.0 -4.8	4.5 -4.8	4.0 -4.8	3.6 -4.6
40	7.6 -4.3	7.0 -4.2	6.4 -4.1	6.0 -4.0	5.5 -3.9	5.1 -4.0	4.6 -4.1	4.0 -4.2	3.5 -4.3
32	7.4 -3.7	6.8 -3.5	6.3 -3.4	5.9 -3.3	5.5 -3.3	5.1 -3.3	4.7 -3.4	4.2 -3.5	3.6 -3.7
24	7.3 -3.1	6.7 -2.9	6.3 -2.8	5.9 -2.8	5.5 -2.8	5.1 -2.8	4.8 -2.8	4.3 -2.9	3.7 -3.1
16	7.2 -2.5	6.6 -2.5	6.2 -2.5	5.9 -2.4	5.5 -2.4	5.1 -2.4	4.8 -2.5	4.4 -2.5	3.9 -2.5
8	7.1 -2.1	6.6 -2.1	6.2 -2.1	5.9 -2.1	5.5 -2.1	5.2 -2.1	4.8 -2.1	4.4 -2.1	3.9 -2.1
0	7.1 -1.7	6.6 -1.7	6.2 -1.7	5.8 -1.7	5.5 -1.7	5.2 -1.7	4.8 -1.7	4.4 -1.7	4.0 -1.7
-8	7.1 -1.3	6.6 -1.4	6.2 -1.4	5.9 -1.4	5.5 -1.4	5.2 -1.4	4.8 -1.4	4.4 -1.4	3.9 -1.3
-16	7.2 -0.9	6.6 -1.0	6.2 -1.0	5.9 -1.0	5.5 -1.0	5.1 -1.0	4.8 -1.0	4.4 -1.0	3.9 -0.9
-24	7.3 -0.4	6.7 -0.5	6.3 -0.6	5.9 -0.6	5.5 -0.6	5.1 -0.6	4.8 -0.6	4.3 -0.5	3.7 -0.4
-32	7.4 0.2	6.8 0.0	6.3 -0.1	5.9 -0.2	5.5 -0.2	5.1 -0.2	4.7 -0.1	4.2 0.0	3.6 0.2
-40	7.6 0.8	7.0 0.7	6.4 0.6	6.0 0.5	5.5 0.5	5.1 0.5	4.6 0.6	4.0 0.7	3.5 0.8
-48	7.4 1.2	7.0 1.3	6.5 1.3	6.0 1.3	5.5 1.3	5.0 1.3	4.5 1.3	4.0 1.3	3.6 1.2

Image correction in x and y given in  $\mu\text{m}$  at 117 image positions at an 8mm grid.





## Results

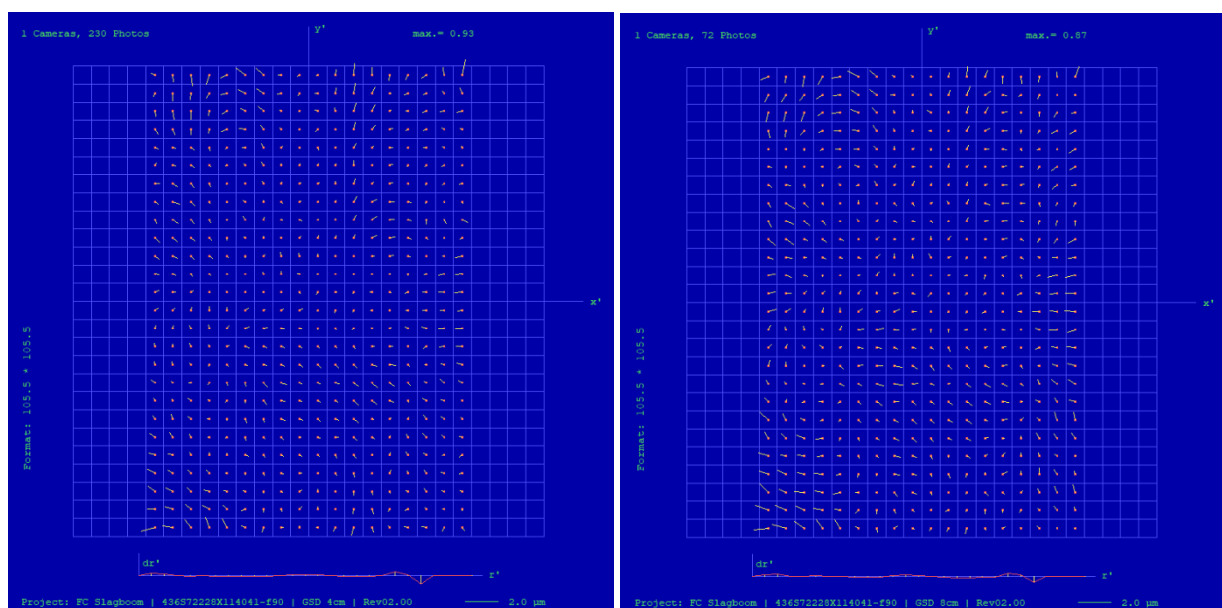
of the Aerial Triangulation with calibration Rev02.00, this field calibration, which includes the geometric adjustments listed above and will serve as the new calibration for the customer.

The data was processed in UltraMap v6.0.4 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 1200m (GSD 4cm)	Flight 2400m (GSD 8cm)
<b>Sigma 0</b>	0.81	0.81
<b>Mean photo scale</b>	1:10455	1:21025
<b>RMSE of 15 check points X/Y/Z</b>	10/12/16mm	11/11/23mm
<b>RMSE of 5 control points X/Y/Z</b>	7/8/12mm	10/15/25mm
<b>Number of used Tiepoints</b>	23604	10703
<b>Refraction Correction</b>	used	used
<b>Earth curvature correction</b>	used	used
<b>Residuals of photo measurements (x', y') in photo space (unit <math>\mu\text{m}</math>):</b>	RMS 0.7, 0.7 MAX 3.8, 3.7	RMS 0.8, 0.7 MAX 3.9, 3.8

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







# ULTRACAM

## Geometric Specifications

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<b>Camera:</b>	<b>UltraCam Eagle 4.1</b>
<b>Serial:</b>	<b>436S72228X114041-f90</b>

<b>Panchromatic Camera:</b>	<b>ck = 90.600 mm</b>
<b>Multispectral Camera:</b>	<b>ck = 90.600 mm</b>

<b>PPA Information:</b>	<b>X: 0.000 mm</b>
	<b>Y: 0.000 mm</b>



## Panchromatic Camera

### Large Format Panchromatic Output Image

<b>Image Format</b>	long track cross track	67.906mm 105.694mm	18060pixel 28110pixel
<b>Image Extent</b>		(-33.953, -52.847)mm	(33.953, 52.847)mm
<b>Pixel Size</b>		3.760μm * 3.760μm	
<b>Focal Length</b>	ck	90.600mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002 mm		

## Multispectral Camera

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

<b>Image Format</b>	long track cross track	67.906mm 105.694mm	6020pixel 9370pixel
<b>Image Extent</b>		(-33.953, -52.847)mm	(33.953, 52.847)mm
<b>Pixel Size</b>		11.280μm * 11.280μm	
<b>Focal Length</b>	ck	90.600mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002mm		



## Conclusion

The tables and plots above show acceptable results for the processing with the new camera calibration (Rev02.00). The calibration was verified with two datasets acquired at the same test area and different altitudes. The remaining image distortions are within an acceptable range.

This equipment operates within specifications defined by Vexcel Imaging GmbH.

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