



# ULTRACAM

## Field Calibration Report

Camera: UltraCam Eagle Mark 1  
Serial: UC-E-1-60715585-f100  
Manufacturer: Vexcel Imaging GmbH, A-8010 Graz,  
Austria

Date of Calibration Flight: Nov-26-2022  
Date of Report: Jan-04-2023  
Camera Revision: Rev13.00  
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 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: 26/11/2022
- Number of images: 301 (total)
- Flying heights: 1350m (GSD 7cm)  
2900m (GSD 15cm)
- Number of images: 205 (GSD 7cm)  
96 (GSD 15cm)
- Ground Control Points: 20 (15 were used as check points)
- Postprocessed GPS/IMU: available

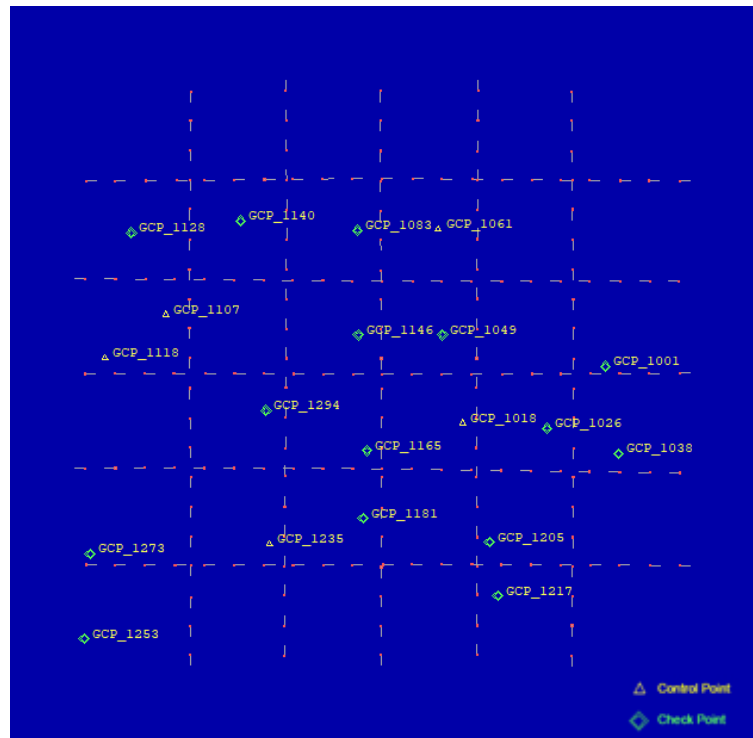
Flight lines look very well done and show good overlap and image quality.

## A-priori standard deviations settings

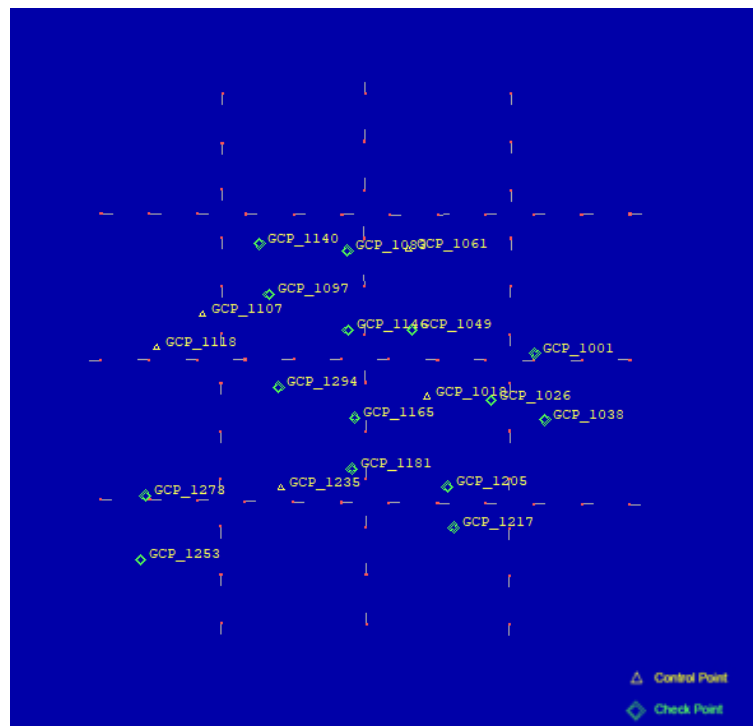
- Image measurements (x,y): 2,6  $\mu$ m
- Ground Control Points (x,y/z): 50 mm / 70 mm
- GNSS Position (x,y/ z): 30 mm / 30 mm
- IMU Pose (p,o/ k): 3 mgon / 5 mgon



- Flight at 1350m (GSD 7cm) :



- Flight at 2900m (GSD 15cm):





## Results

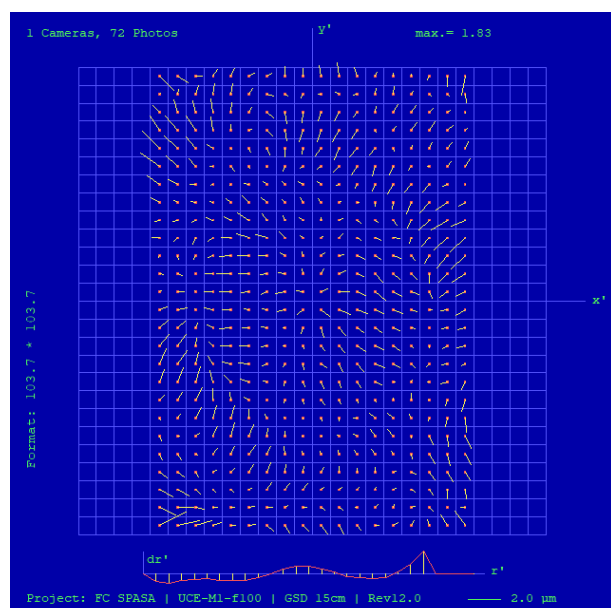
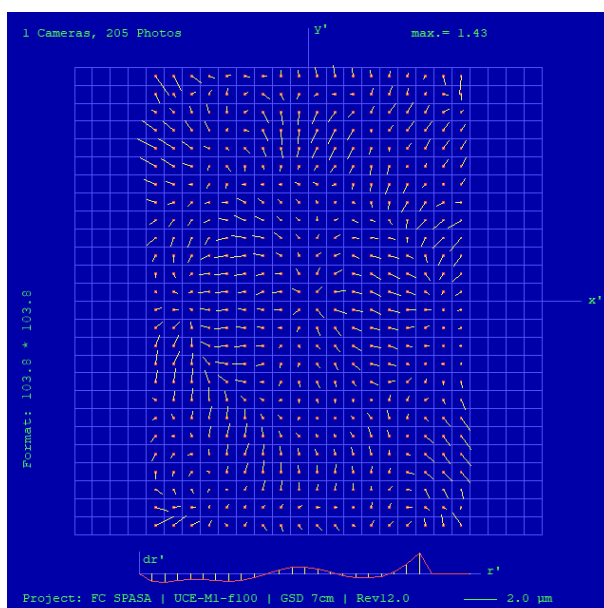
of the Aerial Triangulation with calibration Rev12.00 (labor calibration), as currently used by the customer.

The data was processed in UltraMap v5.6.2 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.

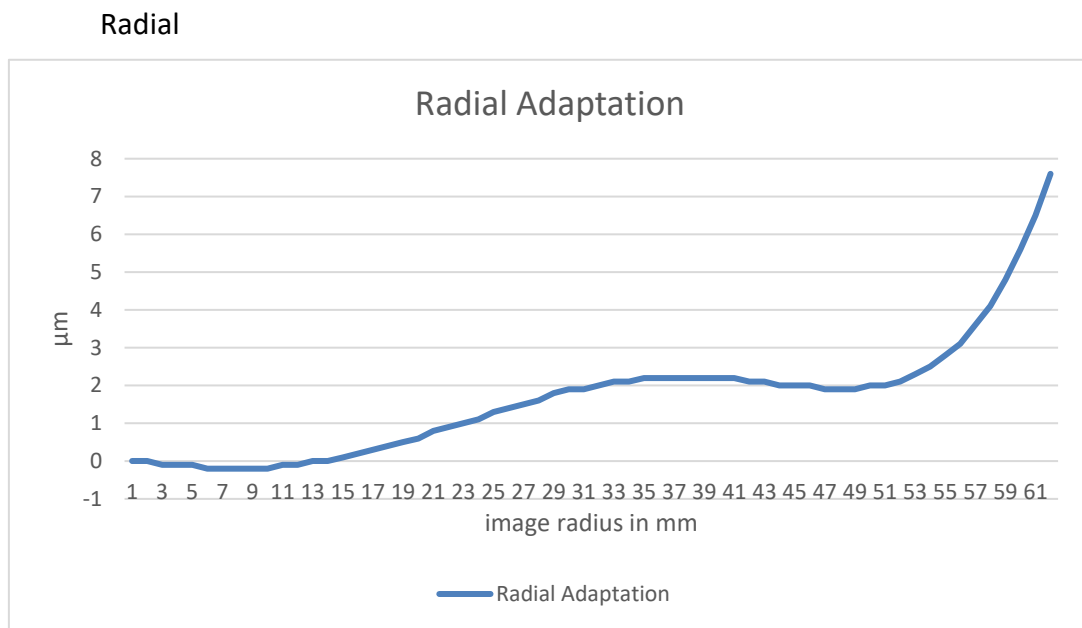
	Flight 1350m (GSD 7cm)	Flight 2900m (GSD 15cm)
<b>Sigma 0</b>	1.03	1.06
<b>Mean photo scale</b>	1:13546	1:29005
<b>RMSE of 15 check points X/Y/Z</b>	41/28/43mm	66/59/35mm
<b>RMSE of 5 control points X/Y/Z</b>	15/13/17mm	51/27/17mm
<b>Number of used Tiepoints</b>	32258	11596
<b>Refraction Correction</b>	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 1.0, 0.8 MAX 5.6, 5.2	RMS 1.0, 0.8 MAX 5.1, 5.1

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





## Adaptations



Focal length	+ 18.5 $\mu\text{m}$
Principal Point	unchanged

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 GSD 7cm and GSD 15cm. 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	4.9 -9.1	4.0 -9.9	2.4 -9.8	1.0 -9.4	-0.4 -9.5	-1.7 -9.7	-3.9 -9.9	-5.3 -9.9	-6.1 -9.1
40	6.2 -8.7	4.4 -8.4	2.6 -7.9	1.0 -7.4	-0.2 -7.3	-1.5 -7.5	-3.6 -7.8	-5.2 -8.3	-6.8 -8.5
32	6.4 -6.7	4.5 -6.3	2.7 -6.0	1.1 -5.6	-0.1 -5.6	-1.3 -5.6	-3.2 -5.8	-4.7 -6.0	-6.5 -6.4
24	6.4 -4.6	4.6 -4.5	3.1 -4.7	1.3 -4.6	0.0 -4.5	-1.2 -4.3	-3.0 -4.3	-4.4 -4.1	-6.0 -4.1
16	5.9 -2.5	4.7 -2.6	3.6 -2.9	1.8 -3.0	0.0 -3.2	-1.8 -3.2	-3.2 -2.7	-4.3 -2.4	-5.7 -2.3
8	5.7 -1.4	4.7 -1.4	3.9 -1.7	2.0 -1.8	0.0 -1.9	-2.0 -1.8	-3.6 -1.4	-4.5 -1.1	-5.6 -1.0
0	5.6 -0.3	4.7 -0.2	3.9 -0.1	2.1 0.0	0.0 0.0	-2.1 0.0	-3.8 0.2	-4.7 0.3	-5.7 0.3
-8	5.5 0.8	4.5 1.1	3.7 1.5	2.0 1.8	0.0 1.9	-2.0 1.8	-3.7 1.9	-4.7 1.7	-5.8 1.7
-16	5.5 1.9	4.3 2.2	3.2 2.7	1.8 3.0	0.0 3.2	-1.8 3.2	-3.5 3.2	-4.6 3.0	-5.9 3.0
-24	5.3 3.4	3.8 3.1	2.7 3.0	1.2 3.7	-0.3 3.9	-1.8 4.0	-3.1 3.7	-4.5 4.0	-6.3 4.5
-32	5.3 5.2	3.7 4.7	2.3 4.3	1.0 4.6	-0.4 4.7	-1.8 4.9	-3.1 4.8	-4.7 5.4	-6.6 6.1
-40	5.1 6.9	3.7 6.7	2.2 6.2	1.0 6.2	-0.5 6.2	-2.0 6.5	-3.3 6.4	-5.0 7.1	-6.7 7.6
-48	3.9 7.0	3.2 8.0	2.0 8.1	1.0 8.1	-0.6 8.2	-2.2 8.3	-3.5 8.0	-4.9 8.2	-5.7 7.5

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





## Results

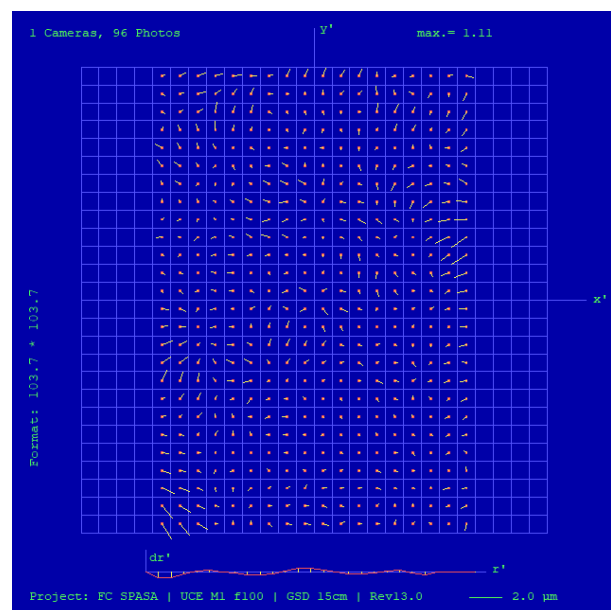
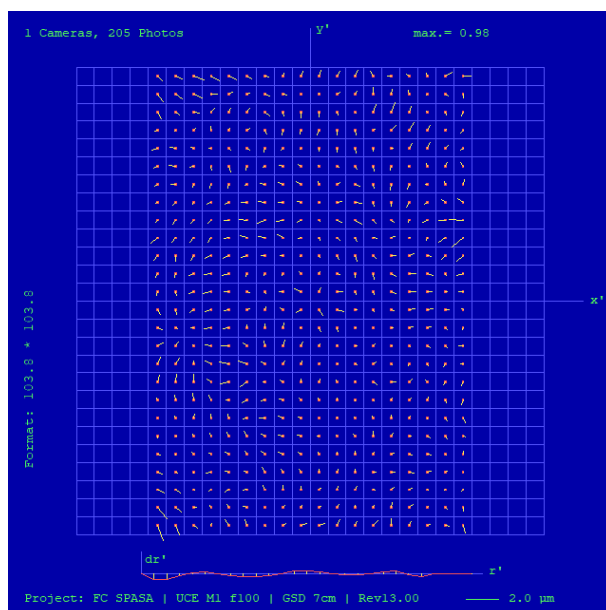
of the Aerial Triangulation with calibration Rev13.00 (field calibration), which will serve as the new calibration for the customer.

The data was processed in UltraMap v5.6.2 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 1350m (GSD 7cm)	Flight 2900m (GSD 15cm)
<b>Sigma 0</b>	0.97	0.98
<b>Mean photo scale</b>	1:13543	1:28998
<b>RMSE of 15 check points X/Y/Z</b>	32/29/27mm	64/44/38mm
<b>RMSE of 5 control points X/Y/Z</b>	17/4/9mm	31/22/16mm
<b>Number of used Tiepoints</b>	32309	14045
<b>Refraction Correction</b>	used	used
<b>Earth curvature correction</b>	used	used
<b>Residuals of photo measurements (x', y') in photo space:</b>	RMS 0.9, 0.8 MAX 5.2, 5.2	RMS 1.0, 0.8 MAX 5.2, 5.2

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</b>
<b>Serial:</b>	<b>UC-E-1-60715585-f100</b>

<b>Panchromatic Camera:</b>	<b>ck = 100.500 mm</b>
<b>Multispectral Camera:</b>	<b>ck = 100.500 mm</b>

<b>PPA Information:</b>	<b>X: -0.104 mm</b>
	<b>Y: 0.000 mm</b>



## Panchromatic Camera

### Large Format Panchromatic Output Image

<b>Image Format</b>	long track cross track	68.016mm 104.052mm	13080pixel 20010pixel
<b>Image Extent</b>		(-34.01, -52.02)mm	(34.01, 52.02)mm
<b>Pixel Size</b>		5.200μm*5.200μm	
<b>Focal Length</b>	ck	100.500mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	-0.104mm	± 0.002mm
	Y_ppa	0.000mm	± 0.002mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002mm		

## Multispectral Camera

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

<b>Image Format</b>	long track cross track	68.016mm 104.052mm	4360pixel 6670pixel
<b>Image Extent</b>		(-34.01, -52.02)mm	(34.01, 52.02)mm
<b>Pixel Size</b>		15.600μm*15.600μm	
<b>Focal Length</b>	ck	100.500mm	± 0.002mm
<b>Principal Point (Level 2)</b>	X_ppa	-0.104mm	± 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 new the camera calibration (Rev13.00). 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.

Dr. Michael Gruber  
Chief Scientist, Photogrammetry  
Vexcel Imaging GmbH

Andreas Bernhart MSc.  
Application Engineer  
Vexcel Imaging GmbH