



# ULTRACAM

## Field Calibration Report

---



**Camera:** UltraCam Eagle Mark 1 f100  
**Serial:** UC-E-1-20816162-f100  
**Manufacturer:** Vexcel Imaging GmbH, A-8010 Graz,  
Austria

**Date of Calibration Flight:** Feb-14-2019  
**Date of Report:** April-12-2020  
**Camera Revision:** Rev06.00  
**Version of Report:** V01

---

**Copyright © 2020 by Vexcel Imaging GmbH, Graz - Austria.**

While every effort is made to ensure its correctness, Vexcel Imaging GmbH assumes no responsibility neither for errors and omissions which may occur in this document nor for damage caused by them.

Vexcel Imaging GmbH does not make a commitment to update the information and software discussed in this document.

All mentioned trademarks or registered trademarks are owned by their respective owners.

Printed in Austria at Vexcel Imaging GmbH. All rights reserved.

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

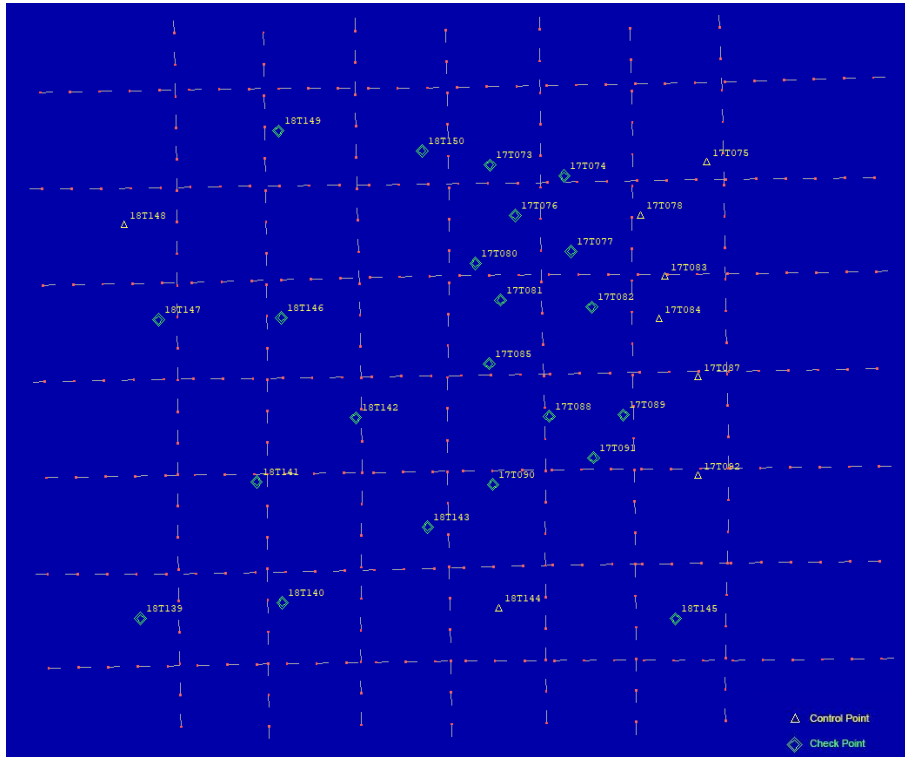
Test flight at customer's test site:

- Date of flight: 14/02/2019
- Number of images: 454 (total)
- Flying heights: 1000 m (GSD 5 cm)  
1950 m (GSD 10 cm)
- Number of images: 364 (GSD 5 cm)  
90 (GSD 10 cm)
- Ground Control Points: 8 (22 were used as check points)
- Postprocessed GPS/IMU: available

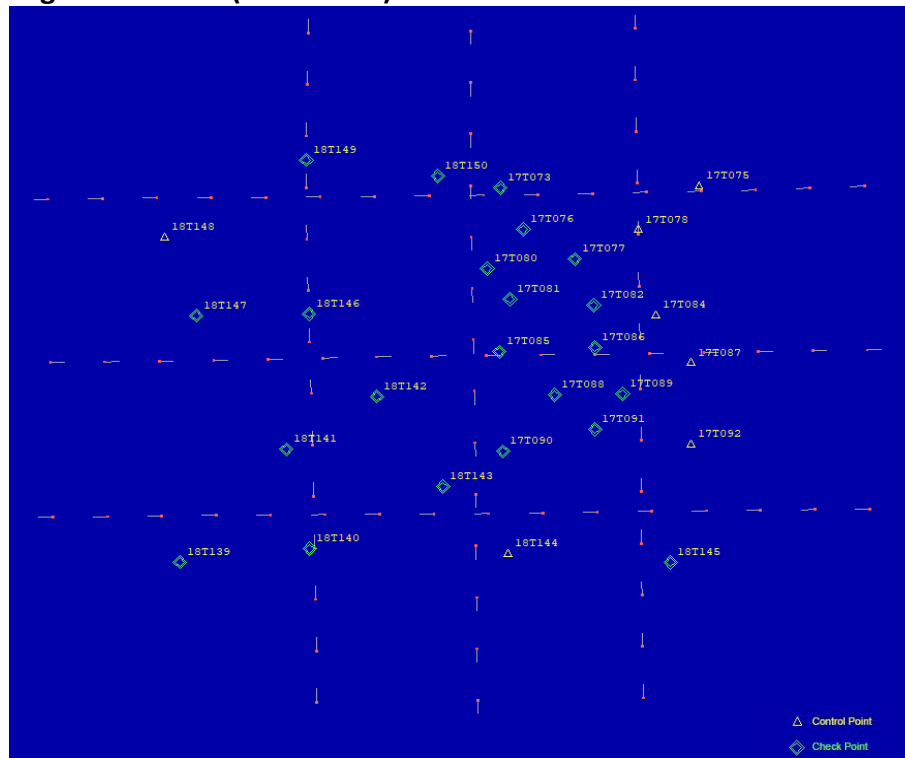
Flight lines look very well done and show good overlap and image quality.



- Flight at 1000 m (GSD 5 cm):



- Flight at 1950 m (GSD 10 cm):





## Results

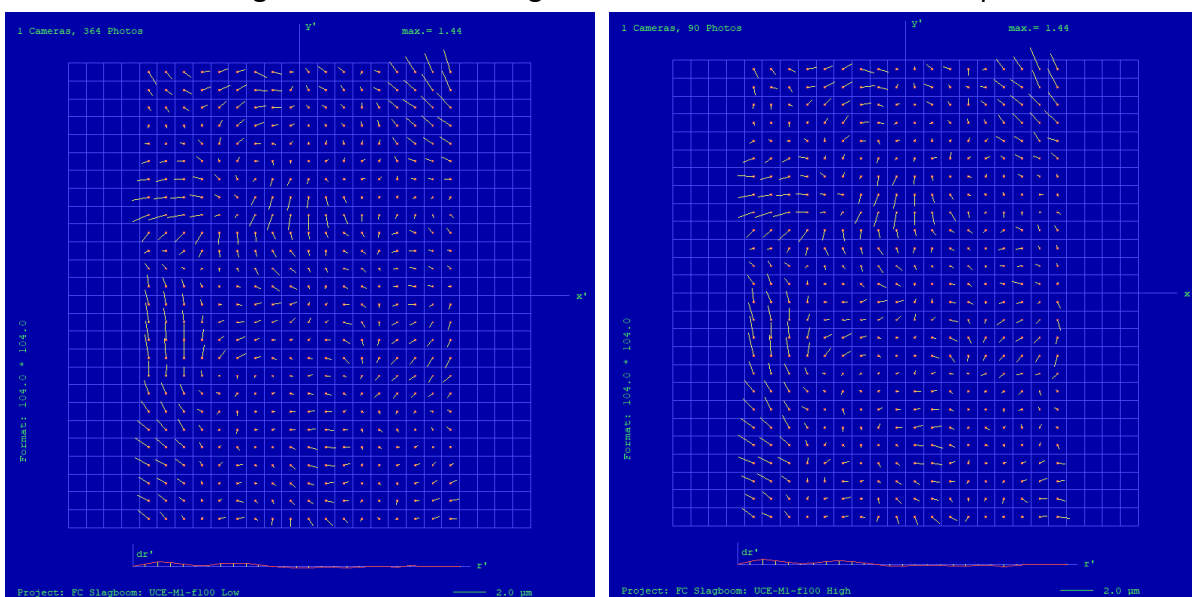
of the Aerial Triangulation with calibration Rev 3 (labor calibration), as currently used by the customer.

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

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

	Flight 1000 m (GSD 5 cm)	Flight 1950 m (GSD 10 cm)
<b>Sigma 0</b>	1.03	1.14
<b>Mean photo scale</b>	1:9963	1:19407
<b>RMSE of 22 check points X/Y/Z</b>	20/12/23 mm	37/31/31 mm
<b>RMSE of 8 control points X/Y/Z</b>	23/17/25 mm	36/26/33 mm
<b>Number of used Tiepoints</b>	49324	13746
<b>Refraction Correction</b>	used	used
<b>Earth curvature correction</b>	used	used
<b>Residuals of photo measurements (x', y') in photo space(unit μm):</b>	RMS 0.9, 0.9 MAX 6.8, 6.7	RMS 1.0, 0.9 MAX 5.2, 5.2

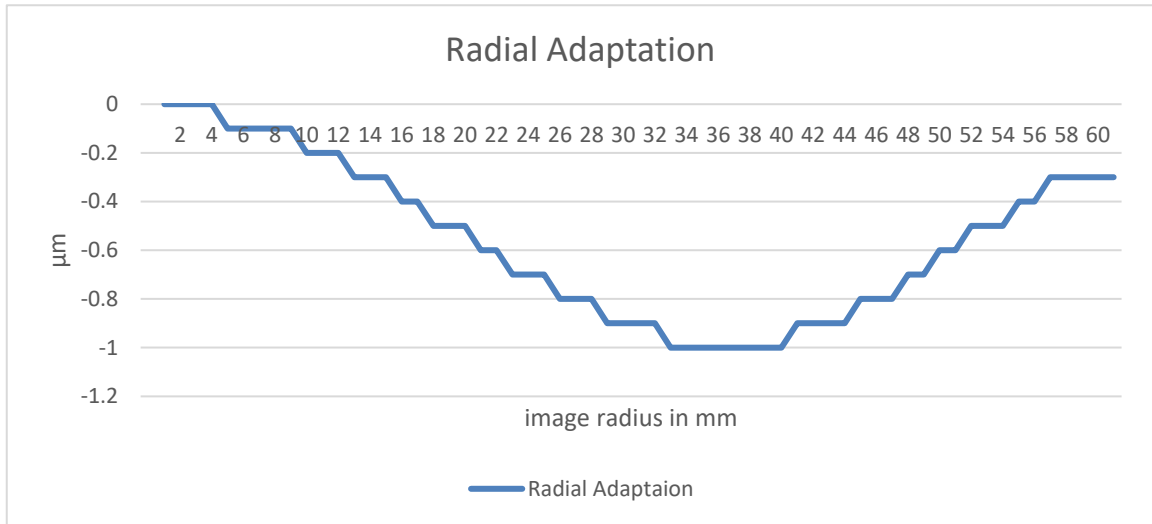
The remaining residuals in the image of the camera are shown in the plots below.





## Geometric Adaptations

### Radial distortion adjustment



Focal length            0.0562 mm  
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 5 cm GSD and 10 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	18.8 -30.3	13.8 -30.7	8.8 -31.0	4.4 -30.7	-0.2 -31.1	-4.9 -31.3	-9.6 -31.2	-14.1 -31.7	-18.6 -32.2
40	19.3 -25.2	14.3 -25.6	9.2 -25.9	4.6 -25.4	-0.1 -25.7	-4.8 -25.9	-9.6 -25.9	-14.2 -26.2	-18.7 -26.5
32	19.8 -20.0	14.8 -20.3	9.7 -20.5	4.8 -19.9	0.1 -20.1	-4.7 -20.2	-9.7 -20.4	-14.3 -20.6	-18.9 -20.7
24	20.4 -14.7	15.3 -14.9	10.1 -15.0	4.9 -14.1	0.2 -14.2	-4.5 -14.3	-9.6 -14.7	-14.3 -14.7	-19.0 -14.7
16	19.6 -8.8	14.8 -8.6	9.9 -8.3	4.7 -8.5	0.0 -8.7	-4.7 -8.9	-9.6 -9.1	-14.1 -9.2	-18.5 -9.2
8	19.4 -4.9	14.6 -4.6	9.6 -4.2	4.6 -4.2	0.0 -4.3	-4.6 -4.4	-9.3 -4.4	-13.9 -4.5	-18.4 -4.6
0	19.2 -1.0	14.3 -0.6	9.4 -0.2	4.6 0.0	0.0 0.0	-4.6 0.0	-9.2 0.2	-13.7 0.2	-18.2 0.2
-8	18.9 2.9	14.0 3.4	9.1 3.8	4.6 4.2	0.0 4.3	-4.6 4.4	-9.0 4.8	-13.6 4.9	-18.0 4.9
-16	18.5 6.7	13.8 7.4	8.9 7.9	4.7 8.5	0.0 8.7	-4.7 8.9	-8.9 9.5	-13.4 9.6	-17.8 9.6
-24	19.3 12.2	14.4 12.8	9.4 13.3	4.8 13.3	0.0 13.4	-4.8 13.5	-8.8 13.7	-13.4 13.8	-17.8 13.9
-32	19.2 16.8	14.3 17.4	9.4 17.8	4.8 17.9	0.0 18.1	-4.8 18.1	-8.9 18.3	-13.5 18.3	-18.1 18.3
-40	19.0 21.3	14.2 21.7	9.4 22.1	4.8 22.4	0.0 22.5	-4.8 22.6	-8.9 22.6	-13.6 22.6	-18.3 22.6
-48	18.9 25.8	14.1 26.0	9.3 26.2	4.7 26.7	0.0 26.8	-4.7 26.8	-8.9 26.8	-13.7 26.8	-18.6 26.8

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



### Results

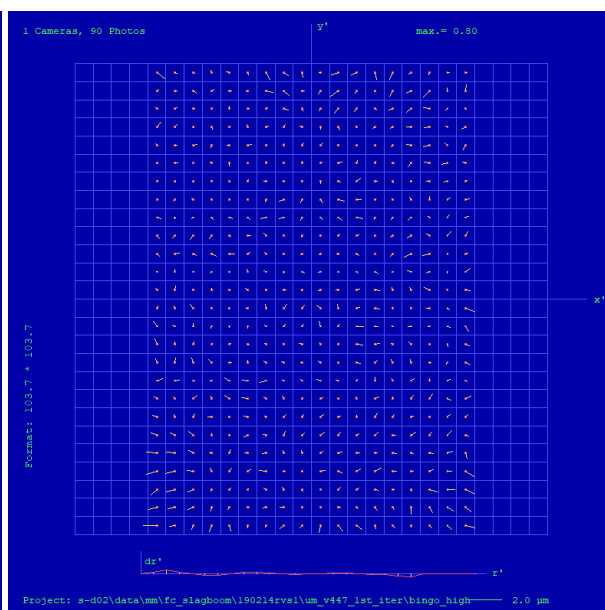
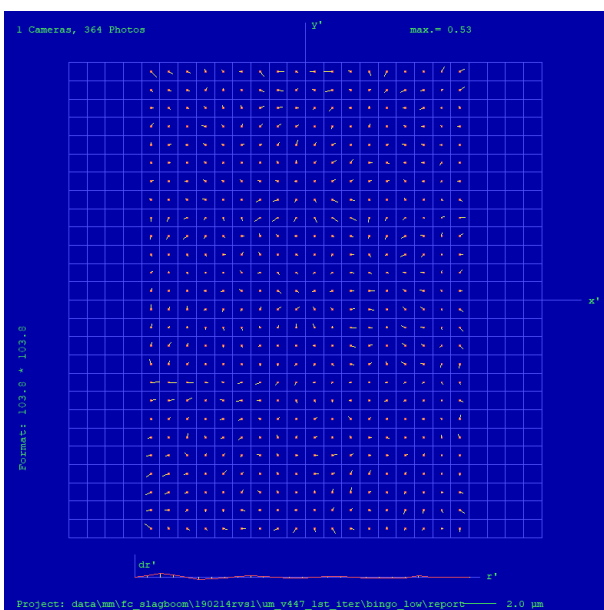
of the Aerial Triangulation with calibration Rev. 04 (field calibration), which will serve as the new calibration for the customer.

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

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

	Flight 1000 m (GSD 5 cm)	Flight 1950 m (GSD 10cm)
<b>Sigma 0</b>	0.94	1.08
<b>Mean photo scale</b>	1:9958	1:19395
<b>RMSE of 22 check points X/Y/Z</b>	14/12/15 mm	20/18/23 mm
<b>RMSE of 8 control points X/Y/Z</b>	14/9/16 mm	22/20/19 mm
<b>Number of used Tiepoints</b>	49375	13744
<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 6.3, 6.2	RMS 1.0, 0.9 MAX 5.7, 5.1

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







# **ULTRACAM**

## Geometric Specifications

---

<b>Camera:</b>	<b>UltraCam Eagle</b>
<b>Serial:</b>	<b>UC-E-1-20816162-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: 0.000 mm</b>
	<b>Y: 0.000 mm</b>



## Panchromatic Camera

### Large Format Panchromatic Output Image

<b>Image Format</b>	long track cross track	68.016 mm 104.052 mm	13080 pixel 20010 pixel
<b>Image Extent</b>		(-34.01, -52.02) mm	(34.01, 52.02) mm
<b>Pixel Size</b>		5.200 μm*5.200 μm	
<b>Focal Length</b>	ck	100.500 mm	± 0.002 mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000mm	± 0.002 mm
	Y_ppa	0.000 mm	± 0.002 mm
<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	68.016 mm 104.052 mm	4360 pixel 6670 pixel
<b>Image Extent</b>		(-34.01, -52.02) mm	(34.01, 52.02) mm
<b>Pixel Size</b>		15.600 μm*15.600 μm	
<b>Focal Length</b>	ck	100.500 mm	± 0.002 mm
<b>Principal Point (Level 2)</b>	X_ppa	0.000 mm	± 0.002 mm
	Y_ppa	0.000 mm	± 0.002 mm
<b>Lens Distortion</b>	Remaining Distortion less than 0.002 mm		



## 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.

A handwritten signature in purple ink, appearing to read "Michael Gruber".

Dr. Michael Gruber  
Chief Scientist, Photogrammetry  
Vexcel Imaging GmbH

A handwritten signature in blue ink, appearing to read "Marc Muick".

Marc Muick MSc.  
Application Specialist  
Vexcel Imaging GmbH