




VEXCEL
IMAGING

ULTRACAM

Field Calibration Report



Camera: UltraCam Eagle
Serial: 431S72012X718520-f100
Manufacturer: Vexcel Imaging GmbH, A-8010 Graz,
Austria

Date of Calibration Flight: Jan-18-2024
Date of Report: Feb-02-2024
Camera Revision: Rev04.00
Version of Report: V0

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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: 18/1/2024
- Number of images: 312 (total)
- Flying heights: 1080m (GSD 4cm)
2160m (GSD 9cm)
- Number of images: 252 (GSD 4cm)
60 (GSD 9cm)
- Ground Control Points: 20 (15 were used as check points)
- Postprocessed GPS/IMU: available

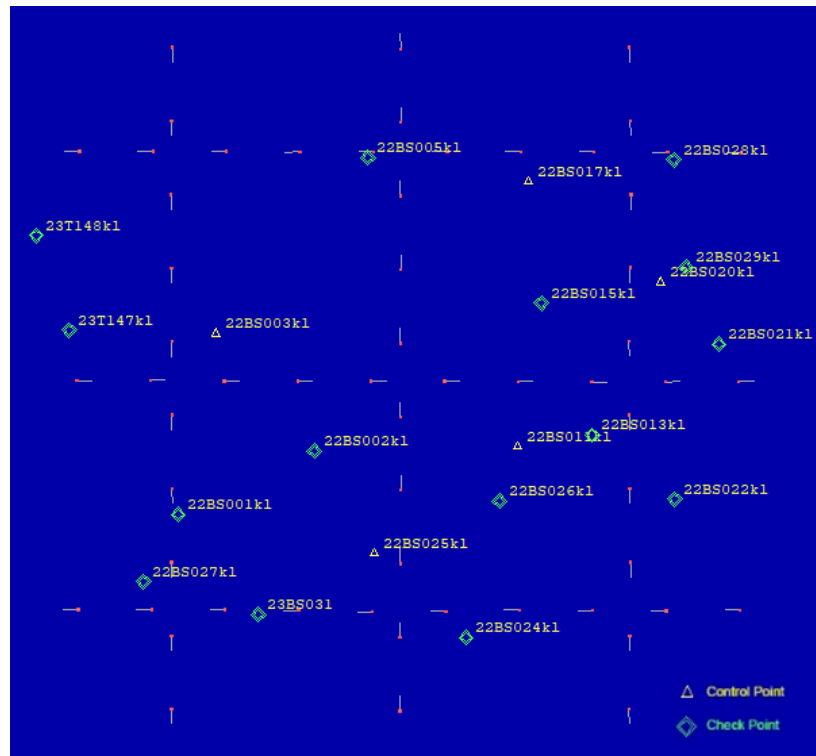
Flight lines look very well done and show good overlap and image quality.

A-priori standard deviations settings

- Image measurements (x,y): 2.0 μ m
- Ground Control Points (x,y/z): 50mm / 70mm
- GNSS Position (x,y/ z): 50mm / 50mm
- IMU Pose (p,o/ k): 3mgon / 4mgon



- **Flight at 2160m (GSD 9cm):**





Results

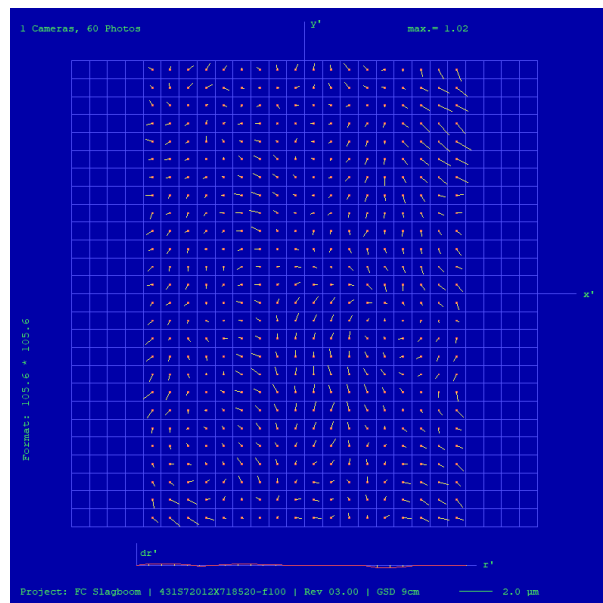
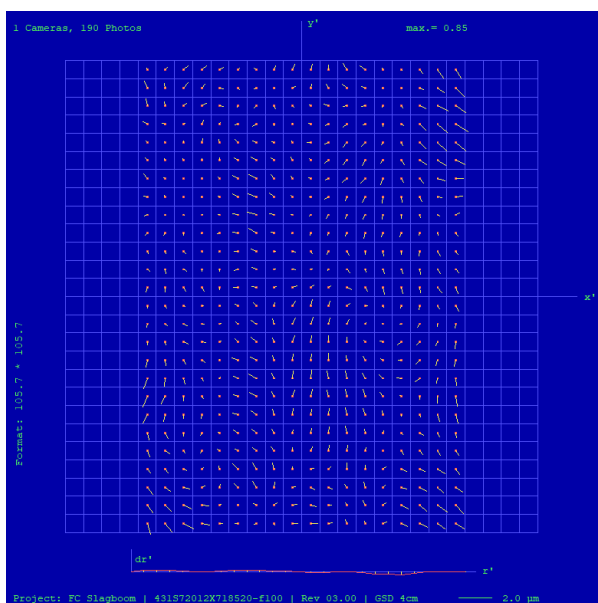
of the Aerial Triangulation with calibration Rev 03.00 (field calibration), as currently used by the customer.

The data was processed in UltraMap v6.2 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 1080m (GSD 4cm)	Flight 2160m (GSD 9cm)
Sigma 0	0.77	0.81
Mean photo scale	1:10555	1:21146
RMSE of 15 check points X/Y/Z	39/36/19mm	92/57/31mm
RMSE of 5 control points X/Y/Z	29/32/18mm	57/44/14mm
Number of used Tiepoints	26713	9521
Refraction Correction	used	Used
Earth curvature correction	used	used
Residuals of photo measurements (x', y') in photo space (unit μm):	RMS 0.7, 0.6 MAX 4.0, 4.0	RMS 0.7, 0.7 MAX 4.0, 4.3

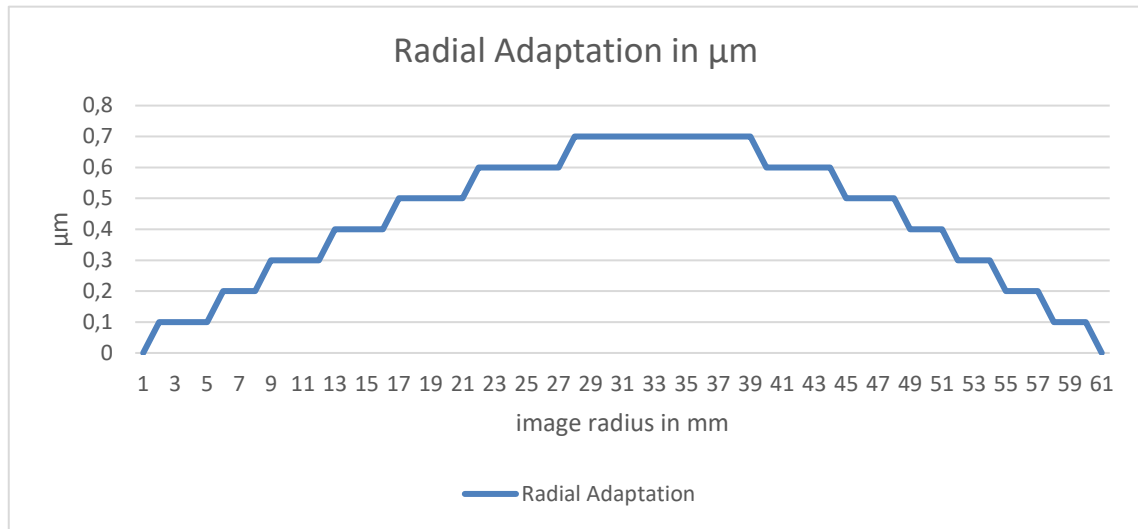
The remaining residuals in the image of the camera are shown in the plots below.





Adaptations

Radial



Focal length - 6.35 μm

Principal Point (x/y) -2.5 μm / 7.8 μm

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 4cm and GSD 9cm. 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	-1.3 6.0	-1.7 6.1	-2.0 6.2	-2.3 6.3	-2.5 6.4	-2.8 6.3	-3.0 6.2	-3.4 6.1	-3.7 6.0
40	-1.4 6.5	-1.8 6.6	-2.1 6.8	-2.3 6.8	-2.5 6.9	-2.7 6.8	-2.9 6.8	-3.2 6.6	-3.6 6.5
32	-1.6 6.9	-1.9 7.1	-2.2 7.2	-2.3 7.2	-2.5 7.2	-2.7 7.2	-2.9 7.2	-3.1 7.1	-3.4 6.9
24	-1.7 7.2	-2.0 7.3	-2.2 7.4	-2.4 7.5	-2.5 7.5	-2.6 7.5	-2.8 7.4	-3.0 7.3	-3.3 7.2
16	-1.8 7.5	-2.1 7.6	-2.3 7.6	-2.4 7.6	-2.5 7.6	-2.6 7.6	-2.7 7.6	-2.9 7.6	-3.2 7.5
8	-1.9 7.7	-2.1 7.7	-2.3 7.7	-2.4 7.7	-2.5 7.7	-2.6 7.7	-2.7 7.7	-2.9 7.7	-3.1 7.7
0	-1.9 7.8	-2.1 7.8	-2.3 7.8	-2.4 7.8	-2.5 7.8	-2.6 7.8	-2.7 7.8	-2.9 7.8	-3.1 7.8
-8	-1.9 8.0	-2.1 8.0	-2.3 7.9	-2.4 7.9	-2.5 7.9	-2.6 7.9	-2.7 7.9	-2.9 8.0	-3.1 8.0
-16	-1.8 8.2	-2.1 8.1	-2.3 8.1	-2.4 8.1	-2.5 8.0	-2.6 8.1	-2.7 8.1	-2.9 8.1	-3.2 8.2
-24	-1.7 8.4	-2.0 8.3	-2.2 8.3	-2.4 8.2	-2.5 8.2	-2.6 8.2	-2.8 8.3	-3.0 8.3	-3.3 8.4
-32	-1.6 8.8	-1.9 8.6	-2.2 8.5	-2.3 8.5	-2.5 8.4	-2.7 8.5	-2.9 8.5	-3.1 8.6	-3.4 8.8
-40	-1.4 9.2	-1.8 9.0	-2.1 8.9	-2.3 8.8	-2.5 8.8	-2.7 8.8	-2.9 8.9	-3.2 9.0	-3.6 9.2
-48	-1.3 9.7	-1.7 9.5	-2.0 9.4	-2.3 9.3	-2.5 9.3	-2.8 9.3	-3.0 9.4	-3.4 9.5	-3.7 9.7

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



Results

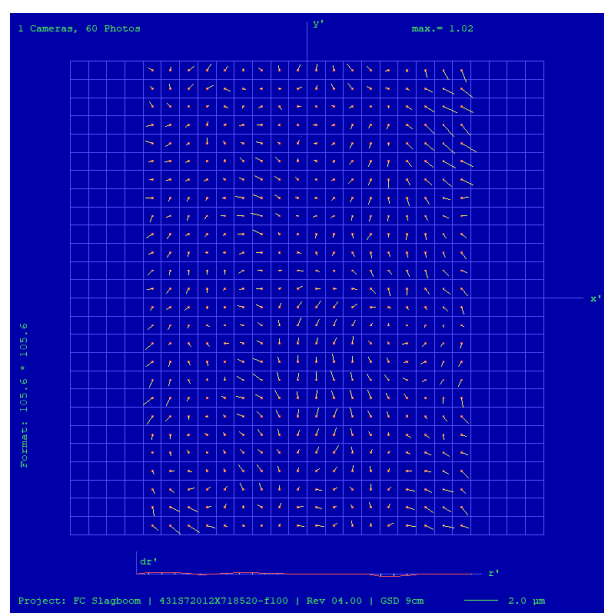
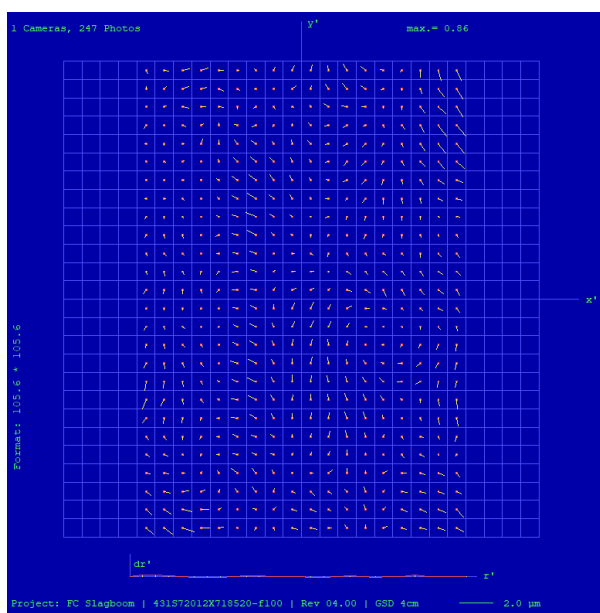
of the Aerial Triangulation with calibration Rev 04.00 (field calibration), which will serve as the new calibration for the customer.

The data was processed in UltraMap v6.2 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 1080m (GSD 4cm)	Flight 2160m (GSD 9cm)
Sigma 0	0.78	0.8
Mean photo scale	1:10594	1:21148
RMSE of 15 check points X/Y/Z	8/15/23mm	10/13/29mm
RMSE of 5 control points X/Y/Z	6/11/14mm	11/9/18mm
Number of used Tiepoints	32205	9455
Refraction Correction	used	Used
Earth curvature correction	used	Used
Residuals of photo measurements (x', y') in photo space:	RMS 0.7, 0.7 MAX 4.0, 4.0	RMS 0.4, 0.7 MAX 4.0, 4.0

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





ULTRACAM

Geometric Specifications

Camera:	UltraCam Eagle M3
Serial:	431S72012X718520-f100

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

PPA Information:	X: 0.000 mm
	Y: 0.000 mm



Panchromatic Camera

Large Format Panchromatic Output Image

Image Format	long track	68.016mm	17004pixel
	cross track	105.840mm	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	0.000mm	± 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	68.016mm	5668pixel
	cross track	105.840mm	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	0.000mm	± 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 the camera calibration (Rev04.00). 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 operates within specifications defined by Vexcel Imaging GmbH.

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Appendix II

Calibration and Modification Dates

Type of Calibration	Laboratory Calibration Date	Modification Date	Modification Reason
Geometric Calibration	03.Sep.2021	22.Jan.2024	Field Calibration
Radiometric Calibration	03.Sep.2021	03.Sep.2021	
Shutter Calibration	03.Sep.2021	03.Sep.2021	
Electronics and Sensor Calibration	03.Sep.2021	03.Sep.2021	

Note: The above-mentioned Laboratory Calibration Dates represent the dates the camera was calibrated in one of our calibration labs for a full Laboratory Calibration. The Modification date represents a date on which the calibration has been modified due to a calibration enhancement or part exchange. It is an additional information and does not replace the Laboratory Calibration date in any way. With the Modification Reason, always the last modification to the calibration is highlighted.