



# ULTRACAM

## Calibration Report

**Camera:** UltraCam Eagle 4.1  
**Serial:** 436S02752X214251-f90

**Laboratory Calibration Date:** Mar-03-2025  
**Camera Revision:** Rev01.00

**Date of Report:** Jun-05-2025  
**Version of Report:** V01



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Venice, Italy

Photo on page 1 courtesy of Vexcel Imaging GmbH



# **ULTRACAM**

## **Geometric Calibration**

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**Camera:** UltraCam Eagle 4.1  
**Serial:** 436S02752X214251-f90

**Panchromatic Camera:** ck = 90.600 mm  
**Multispectral Camera:** ck = 90.600 mm

**PPA Information Nadir:** X: 0.000 mm  
Y: 0.000 mm



## 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 0.002mm		

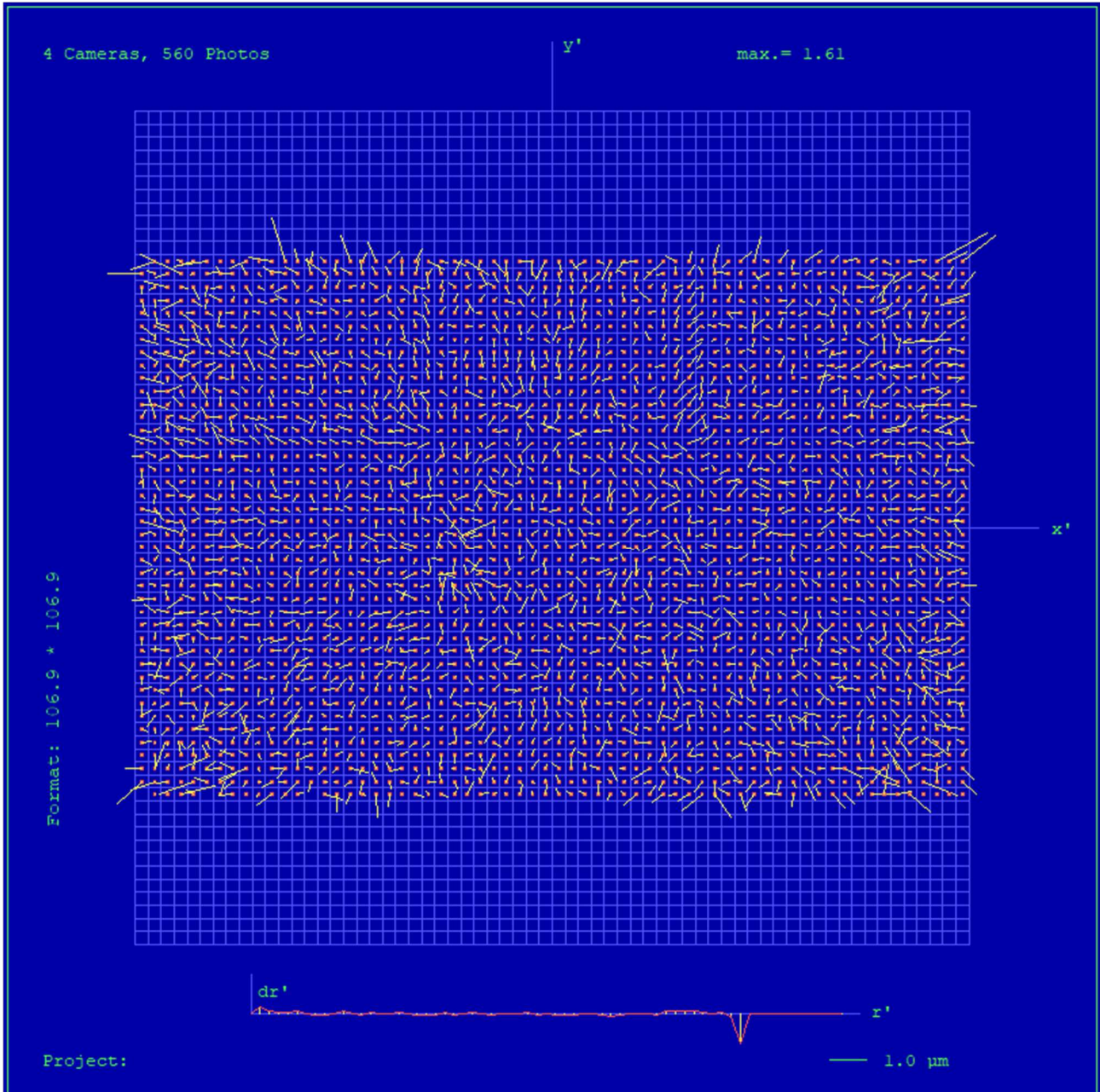
## Multispectral Camera

### 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		



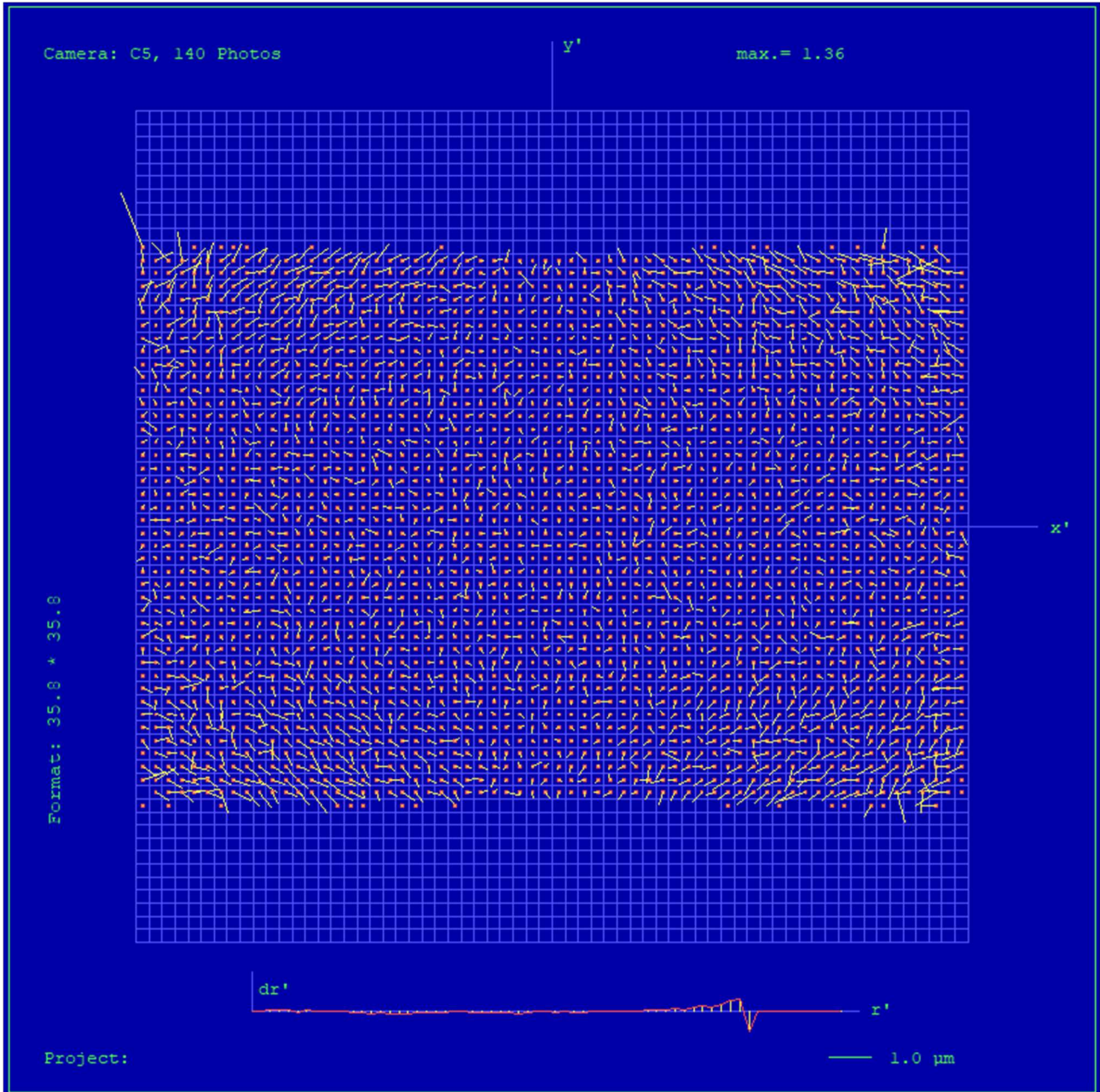
# Full Panchromatic Image, Residual Error Diagram



**Residual Error (RMS):**            **0.46  $\mu\text{m}$**



# Green Cone (Cone 5), Residual Error Diagram



**Residual Error (RMS):**            **0.28  $\mu\text{m}$**



## Explanations

### Calibration Method:

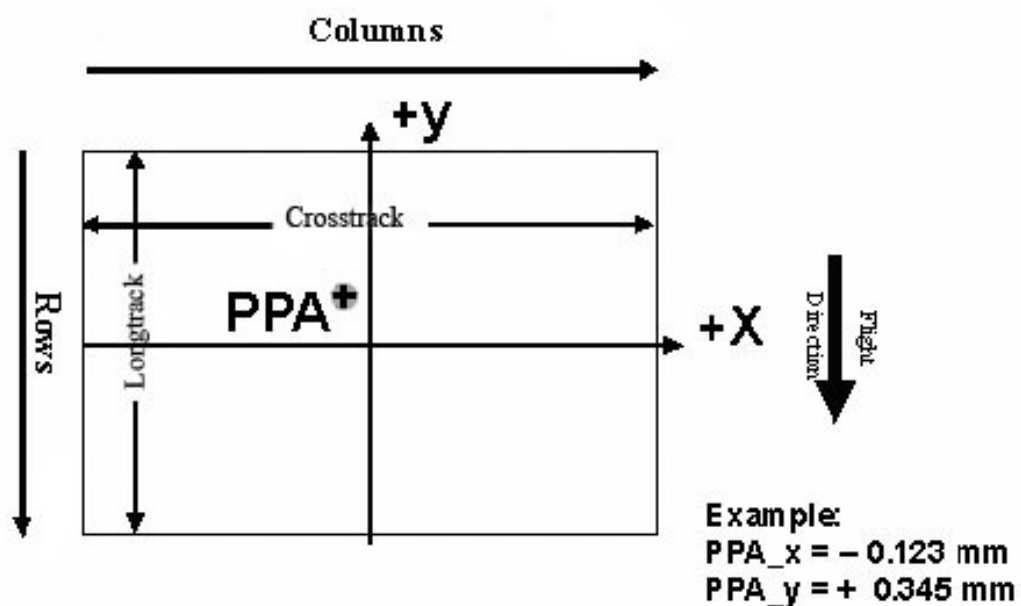
The geometric calibration is based on a set of 140 images of a defined geometry target with 394 GCPs.

Number of point measurements for the panchromatic camera : >16000  
Number of point measurements for the multispectral camera : >60000

Determination of the image parameters by Least Squares Adjustment.  
Software used for the adjustment: BINGO (GIP Eng. Aalen, Germany)

### Level 2 Image Coordinate System:

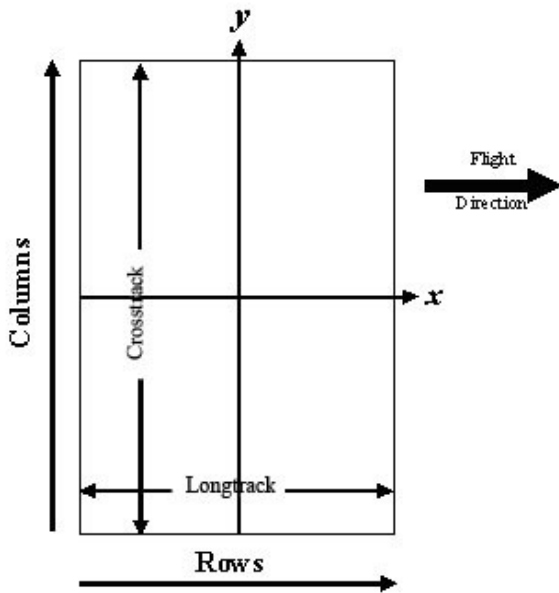
## Lvl2, Camera prop. Orientation



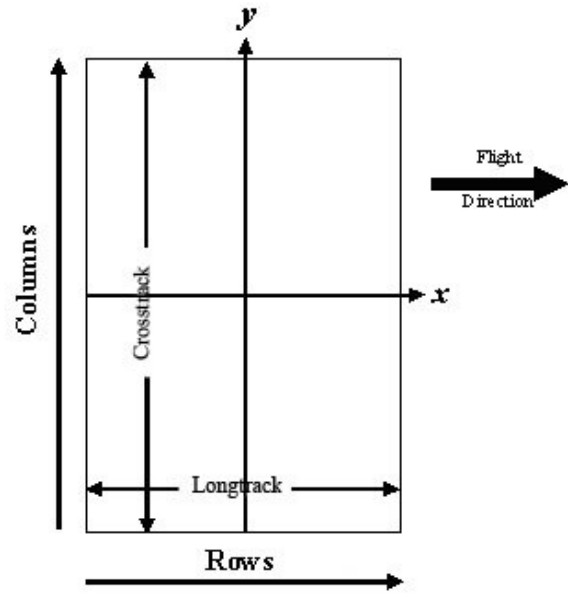
The image coordinate system of the Level 2 images is shown in the above figure. The basic image format and coordinate of the principal point in the level 2 image is given on page 4 of this report. The above figure shows the position of an example principal point at the coordinate (-0.123 / 0.345).



**Level 3 Image Coordinate System:**  
(after rotation of 270° CW)



Panchromatic Image Format



Multispectral Image Format

**Position of Principal Point in Level 3 Image**

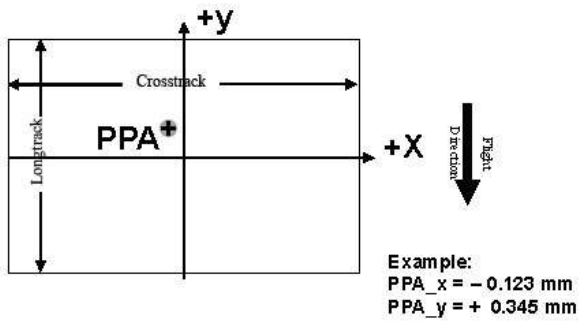
The position of the principal point in the level 3 image depends on the “rotation” setting used in UltraMap during the pan-sharpening step. The exact position relative to the image center is given in the table below as a function of the rotation setting used in UltraMap. The coordinates are specified for clockwise (CW) rotation in steps of 90 degrees, according to the principal point coordinate given on page 4 for high- and low resolution images.

Image Format	Clockwise Rotation (Degree)	PPA	
		X	Y
Level 2	-	0.000	0.000
Level 3	0	0.000	0.000
Level 3	90	0.000	0.000
Level 3	180	0.000	0.000
Level 3	270	0.000	0.000

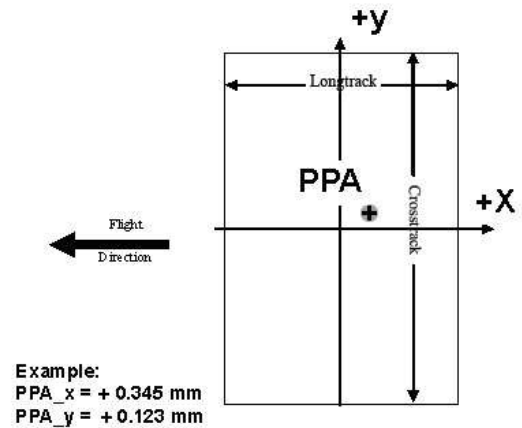


The coordinates in the figure below are only example values to illustrate the effect of image rotation on the principal point position, and do **not** correspond to the camera described in this report.

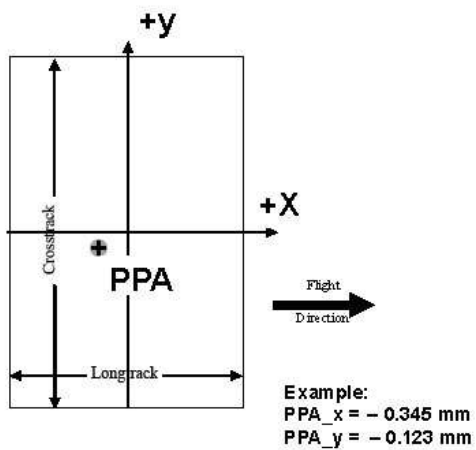
Lvl3, Rotation 0 deg clockwise



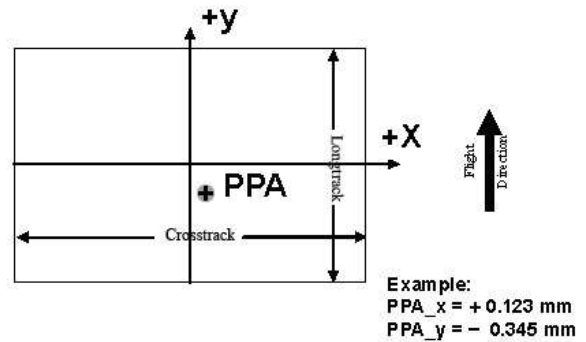
Lvl3, Rotation 90 deg clockwise



Lvl3, Rotation 270 deg clockwise



Lvl3, Rotation 180 deg clockwise





## Lens Resolving Power

The following curves show the development of the modulation transfer function across different image heights of the panchromatic cones.

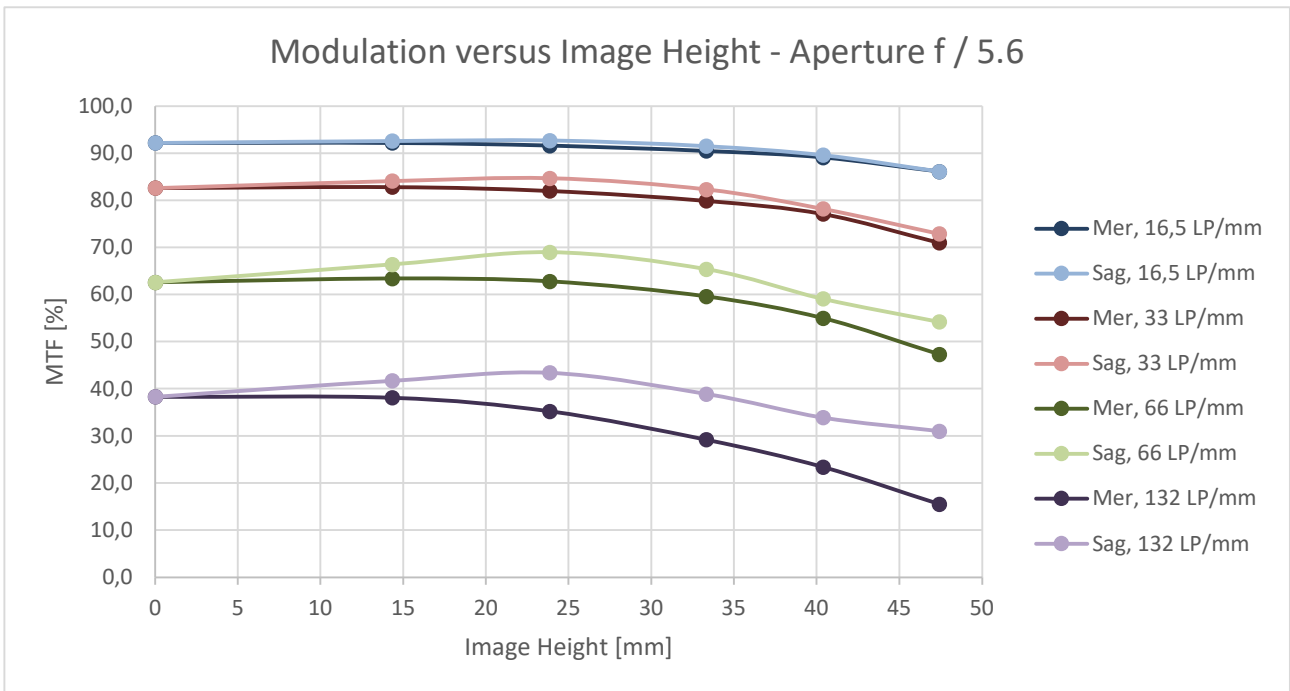
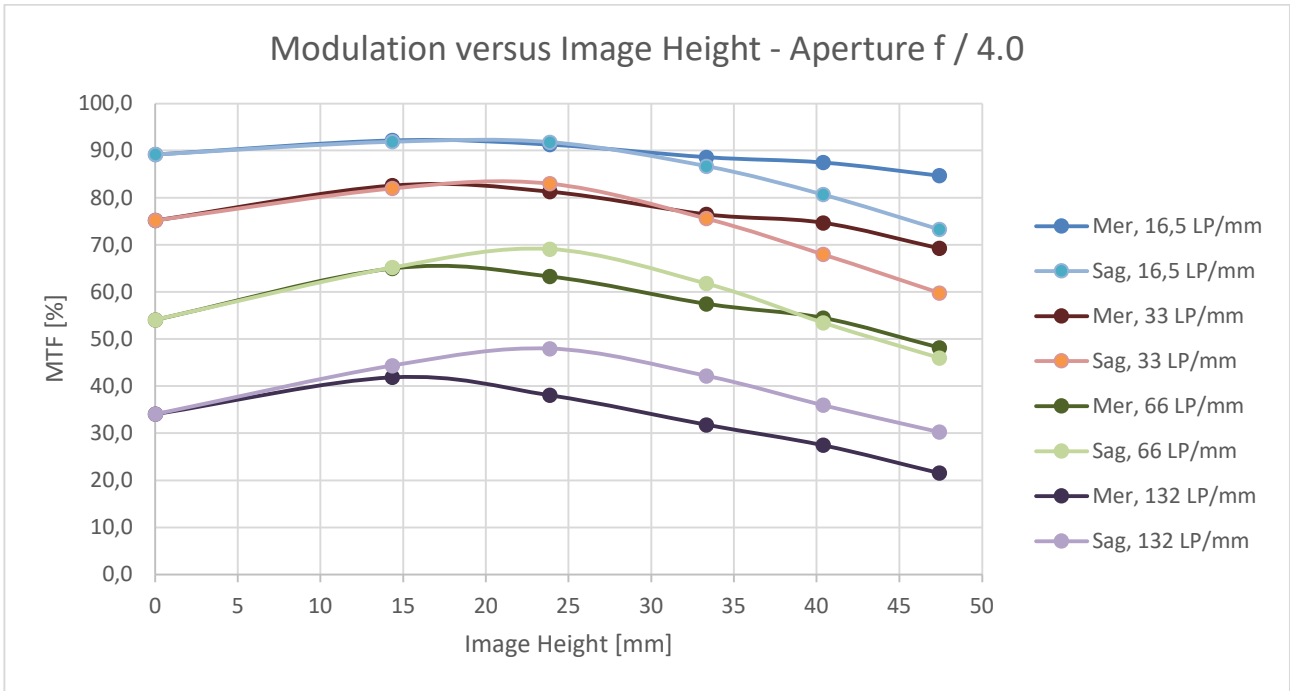
Please note that these values have been calculated and can vary up to 10% with optics from production (especially at high LP's).

The curves are given for the meridional (tangential) and sagittal (radial) component of signals at frequencies of 16.5, 33, 66 and 132 line pairs per millimeter.

As the MTF is a function of the specific aperture size used, one set of curves is given for each aperture size.

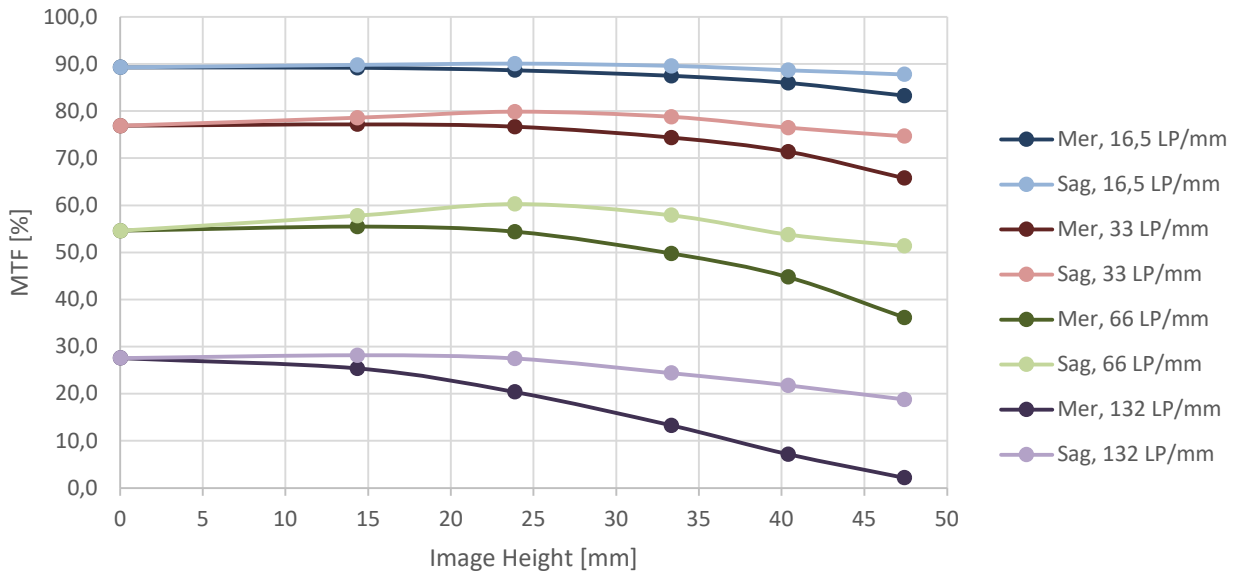
### Lens types

Cone	Lens
C0 (PAN)	Qioptic Vexcel HR Digaron 1:5.6/90mm, Qioptic GmbH, Germany
C1 (PAN)	Qioptic Vexcel HR Digaron 1:5.6/90mm, Qioptic GmbH, Germany
C2 (PAN)	Qioptic Vexcel HR Digaron 1:5.6/90mm, Qioptic GmbH, Germany
C3 (PAN)	Qioptic Vexcel HR Digaron 1:5.6/90mm, Qioptic GmbH, Germany
C4 (RED)	Qioptic Vexcel HR Digaron 1:4.8/30mm, Qioptic GmbH, Germany
C5 (GREEN)	Qioptic Vexcel HR Digaron 1:4.8/30mm, Qioptic GmbH, Germany
C6 (BLUE)	Qioptic Vexcel HR Digaron 1:4.8/30mm, Qioptic GmbH, Germany
C7 (NIR)	Qioptic Vexcel HR Digaron 1:4.8/30mm, Qioptic GmbH, Germany

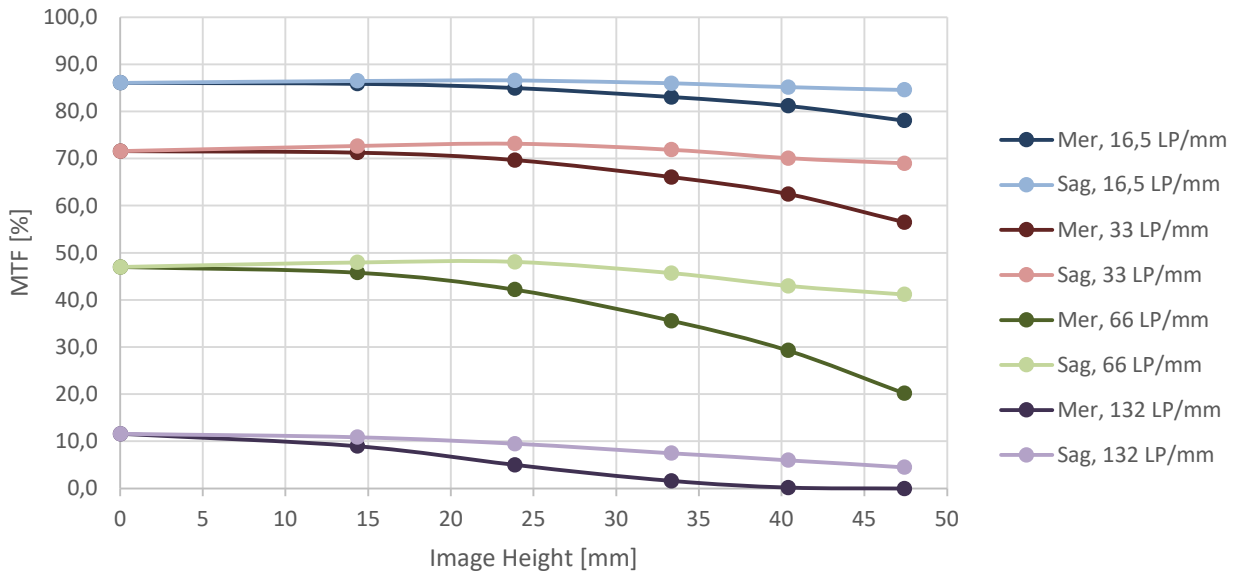




Modulation versus Image Height - Aperture f / 8

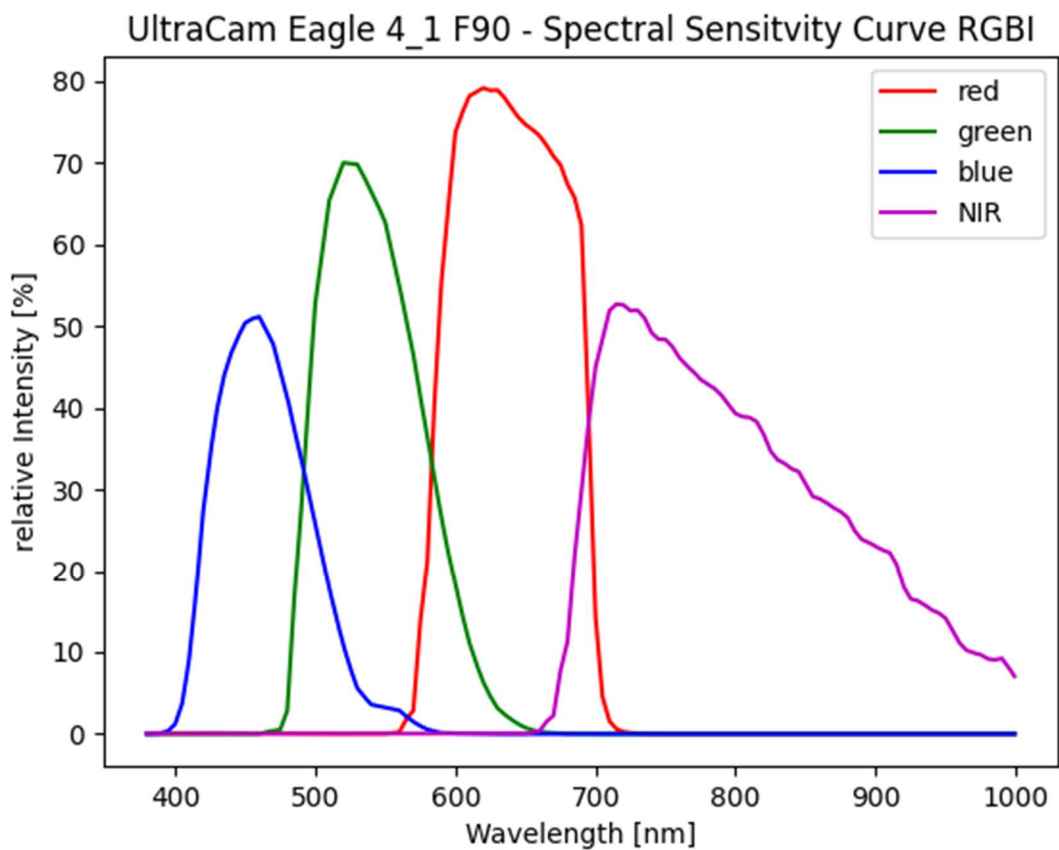
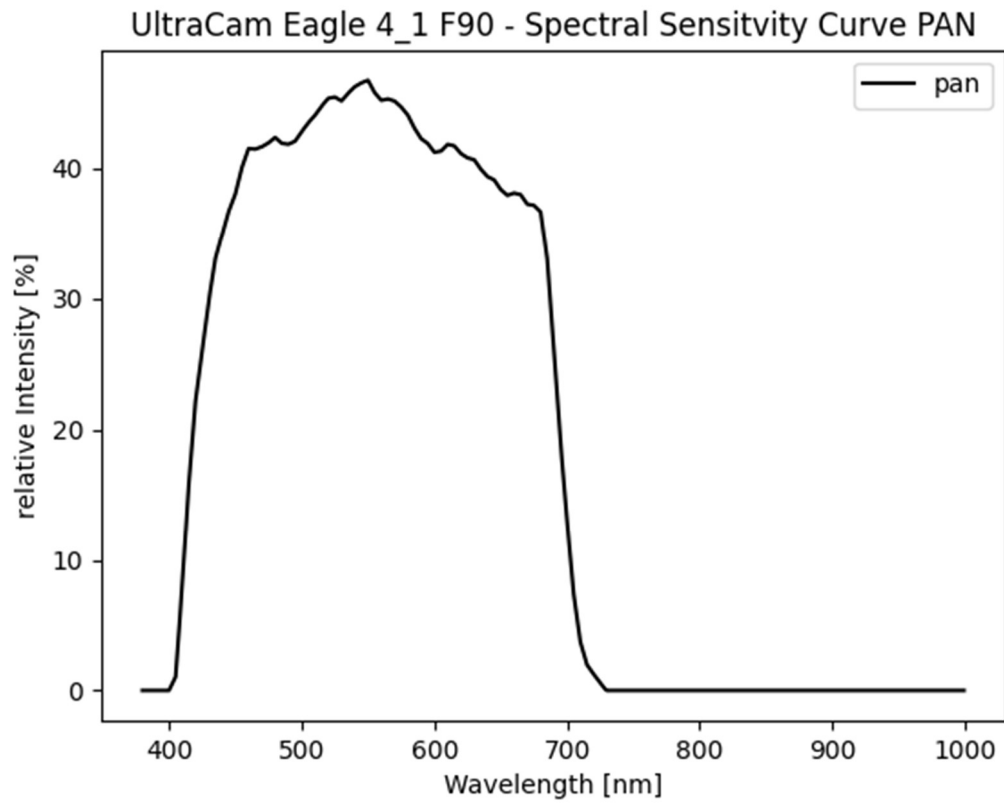


Modulation versus Image Height - Aperture f / 11





## Spectral Sensitivity





# ULTRACAM

## Radiometric Calibration

Camera: UltraCam Eagle 4.1  
Serial: 436S02752X214251-f90

	PAN	R, G, NIR	B
Used Apertures	F5.6	F4.8	F4.8
	F6.7	F5.6	F4.8
	F8	F6.7	F4.8
	F9.5	F8	F5.6
	F11	F9.5	F6.7
	F13	F11	F8
	F16	F13	F9.5
	F22	F19	F13

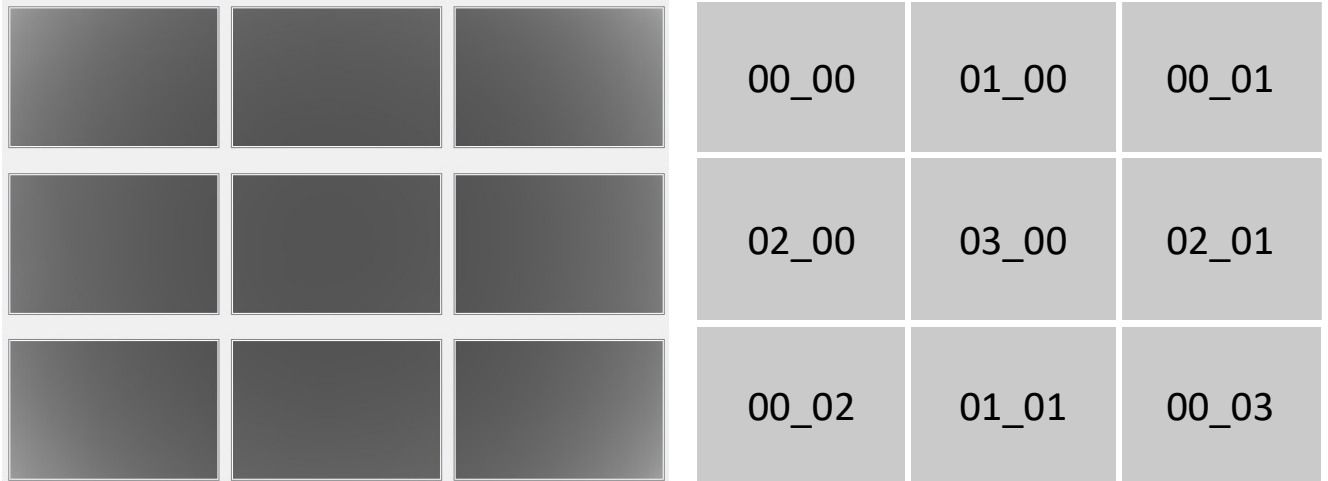
Dead Pixel Report: see Appendix I



### Calibration of Vignetting for working Aperture F5.6

	PAN	R, G, NIR	B
Aperture	F5.6	F4.8	F4.8

Graphical Overview of Pan Sensor Gain Values:



Graphical Overview of Multispectral Sensor Gain Values:





## Explanations

### Calibration Method:

The radiometric calibration is based on a series of 60 flat field images for each aperture size and sensor. The flat field is illuminated by eight normal light lamps with known spectral illumination curves.

These images are used to calculate the specific sensitivity of each pixel to compensate local as well as global variations in sensitivity. Sensitivity tables are calculated for each sensor and aperture setting, and applied during post processing from level 0 to level 1.

Outlier Pixels that do not have a linear behavior as described in the CMOS specifications are marked as defective during the calibration procedure. These pixels are not used or only partially used during post processing and the information is restored by interpolation between the neighborhood pixels surrounding the defective pixels.



# **ULTRACAM**

## Shutter Calibration

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**Camera:** UltraCam Eagle 4.1  
**Serial:** 436S02752X214251-f90

**Panchromatic Camera:** 4 \* Prontor Magnetic 0 HS2  
Prontor-Werk Alfred Gauthier GmbH, Germany

**Multispectral Camera:** 4 \* Prontor Magnetic 0 HS2  
Prontor-Werk Alfred Gauthier GmbH, Germany



### Calibration of Shutter Release Times:

The shutter release times measured during the calibration describe the time from the moment when the electrical current through the shutter is turned off by the electronics, until the shutter is mechanically closed.

This time is relevant for the exposure control and needs to be known before image recording can take place.

Currently used SRT values (operation values):

Cone Number	Lens Serial Number	SRT F5.6 [ms]	SRT F6.7 [ms]	SRT F8 [ms]	SRT F9.5 [ms]	SRT F11 [ms]	SRT F13 [ms]	SRT F16 [ms]	SRT F22 [ms]	Measurement Tolerance [ms]
C0 (Pan)	12 78 09 69	5.55	5.92	6.34	6.62	6.85	7.01	7.17	7.41	+/- 0.2
C1 (Pan)	12 78 09 62	6.11	6.44	6.95	7.21	7.44	7.64	7.72	8.09	+/- 0.2
C2 (Pan)	12 78 09 67	5.46	5.96	6.29	6.51	6.78	6.92	7.06	7.26	+/- 0.2
C3 (Pan)	12 78 09 97	5.80	6.18	6.63	6.92	7.13	7.30	7.44	7.66	+/- 0.2
C4 (Red)	12 77 38 66	7.00	7.11	7.27	7.37	7.48	7.56	7.65	7.73	+/- 0.2
C5 (Green)	12 71 76 93	6.97	7.07	7.22	7.34	7.42	7.48	7.56	7.65	+/- 0.2
C6 (Blue)	12 71 76 94	6.69	6.70	6.68	6.80	6.96	7.03	7.14	7.28	+/- 0.2
C7 (NIR)	12 77 38 68	7.44	7.55	7.71	7.86	7.92	7.99	8.07	8.17	+/- 0.2



# **ULTRACAM**

## Electronics and Sensor Calibration

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**Camera:** UltraCam Eagle 4.1  
**Serial:** 436S02752X214251-f90

**Panchromatic Camera:** 9 \* IMX455-ALK-M CMOS Sensor by SONY  
**Multispectral Camera:** 4 \* IMX455-ALK-M CMOS Sensor by SONY



## Calibration of Intensity Threshold for Exposure Control:

Each CMOS sensor and electronics module varies slightly in global sensitivity and intensity scale.

Therefore the maximum possible intensity of each sensor needs to be measured to evaluate the sensitivity behavior of the CMOS and electronics.

This value is used as a threshold for the exposure control dialogue shown in the in-flight user interface of the Camera.

Currently used Threshold values (operation values):

Cone_Sensor	Sensor Type	Sensor Serial Number	Intensity Threshold [DN]
00_00	IMX455-ALK-M	00001EADF616	16130
00_01	IMX455-ALK-M	00001DD69292	16130
00_02	IMX455-ALK-M	00001EAE414D	16130
00_03	IMX455-ALK-M	00001EAE2D70	16130
01_00	IMX455-ALK-M	00001EADF09B	16130
01_01	IMX455-ALK-M	00001EAE991C	16130
02_00	IMX455-ALK-M	00001EAEAC1D	16130
02_01	IMX455-ALK-M	00001CC8FDD7	16130
03_00	IMX455-ALK-M	00001EAE2641	16100
04_00 (red)	IMX455-ALK-M	00001EAEB748	16130
05_00 (green)	IMX455-ALK-M	00001EAE2F53	16130
06_00 (blue)	IMX455-ALK-M	00001EAE984E	16130
07_00 (NIR)	IMX455-ALK-M	00001EADFC14	16090



# ULTRACAM

## Summary

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<b>Camera:</b>	<b>UltraCam Eagle 4.1</b>
<b>Serial:</b>	<b>436S02752X214251-f90</b>
<b>Laboratory Calibration Date:</b>	<b>Mar-03-2025</b>
<b>Camera Revision:</b>	<b>Rev01.00</b>
<b>Date of Report:</b>	<b>Jun-05-2025</b>
<b>Version of Report:</b>	<b>V01</b>

The following calibrations have been performed for the above mentioned digital aerial mapping camera:

- Geometric Calibration
- Radiometric Calibration
- Shutter Calibration
- Sensor and Electronics Calibration

This equipment is operating fully within specification as defined by Vexcel Imaging GmbH.

Dr. Michael Gruber  
Chief Scientist, Photogrammetry  
Vexcel Imaging GmbH

Dipl. Ing. (FH) Helmut Jauk  
Senior Project Engineer R&D  
Vexcel Imaging GmbH



## Appendix I

### Dead Pixel Report:

Cone_Sensor	Dead Pixel Count
00_00	270
00_01	181
00_02	161
00_03	181
01_00	169
01_01	132
02_00	229
02_01	261
03_00	155
04_00 (red)	131
05_00 (green)	124
06_00 (blue)	119
07_00 (NIR)	161



## Appendix II

### Calibration and Modification Dates

Type of Calibration	Laboratory Calibration Date	Modification Date	Modification Reason
Geometric Calibration	Mar-03-2025		
Radiometric Calibration	Mar-03-2025		
Shutter Calibration	Mar-03-2025		
Electronics and Sensor Calibration	Mar-03-2025		

**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.