

# Calibration Certificate

Digital Mapping Camera (DMC)

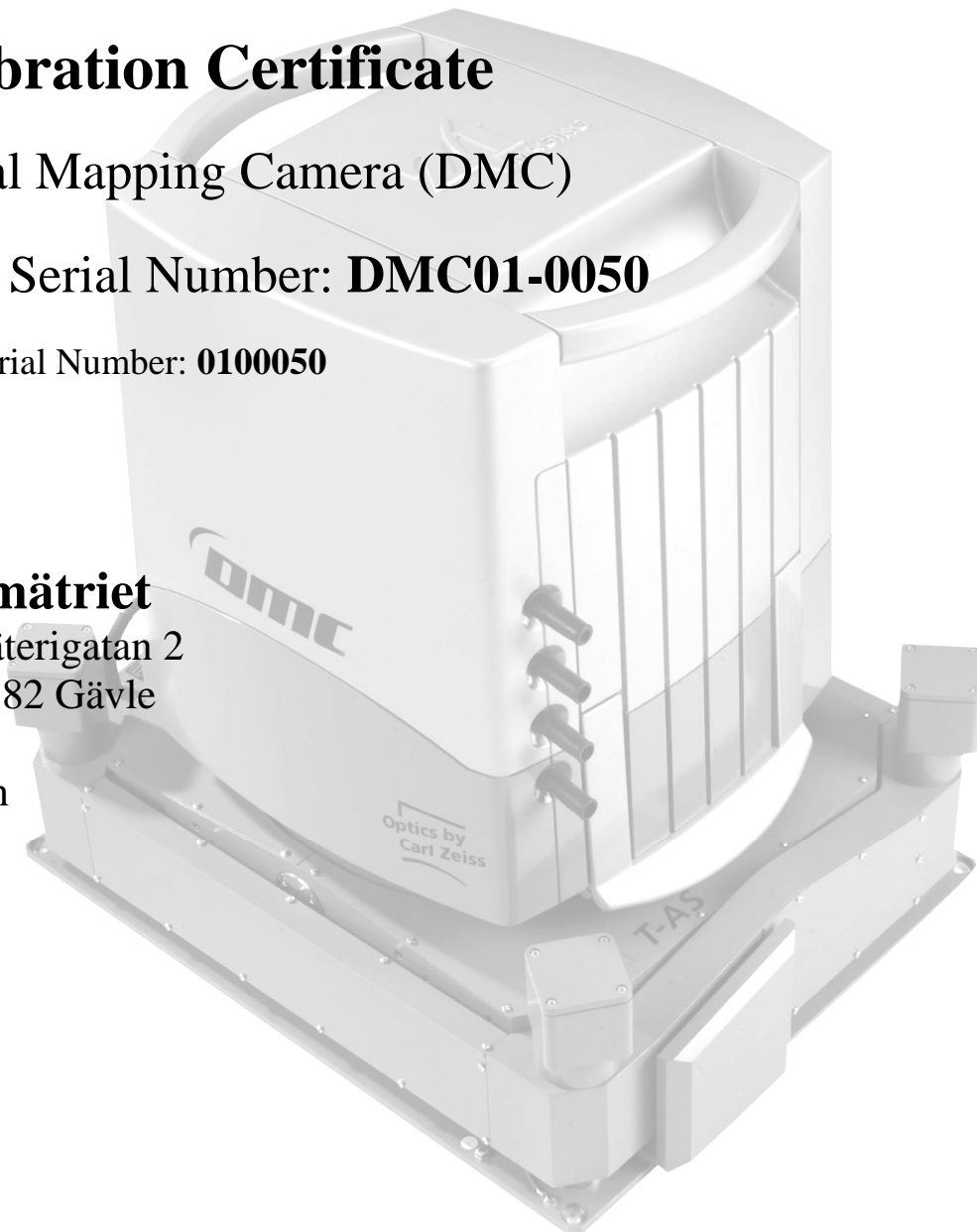
DMC Serial Number: **DMC01-0050**

CBU Serial Number: **0100050**

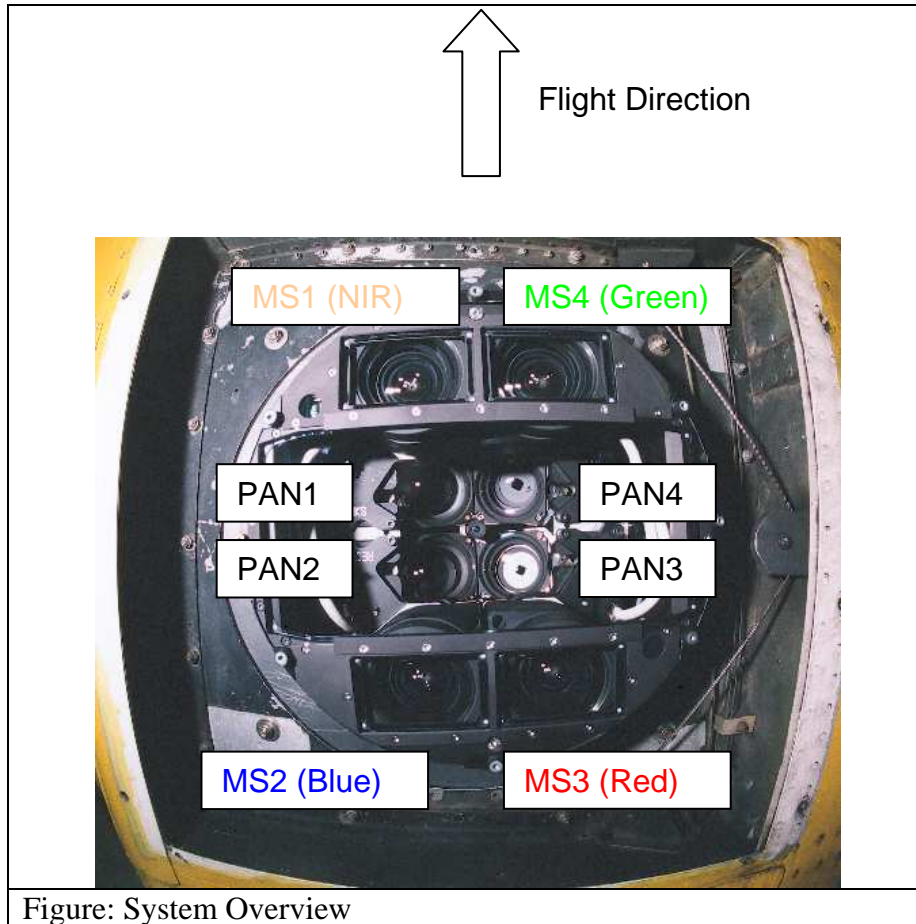
For

**Lantmätriet**  
Lantmäterigatan 2  
SE-80182 Gävle

Sweden



## System Overview



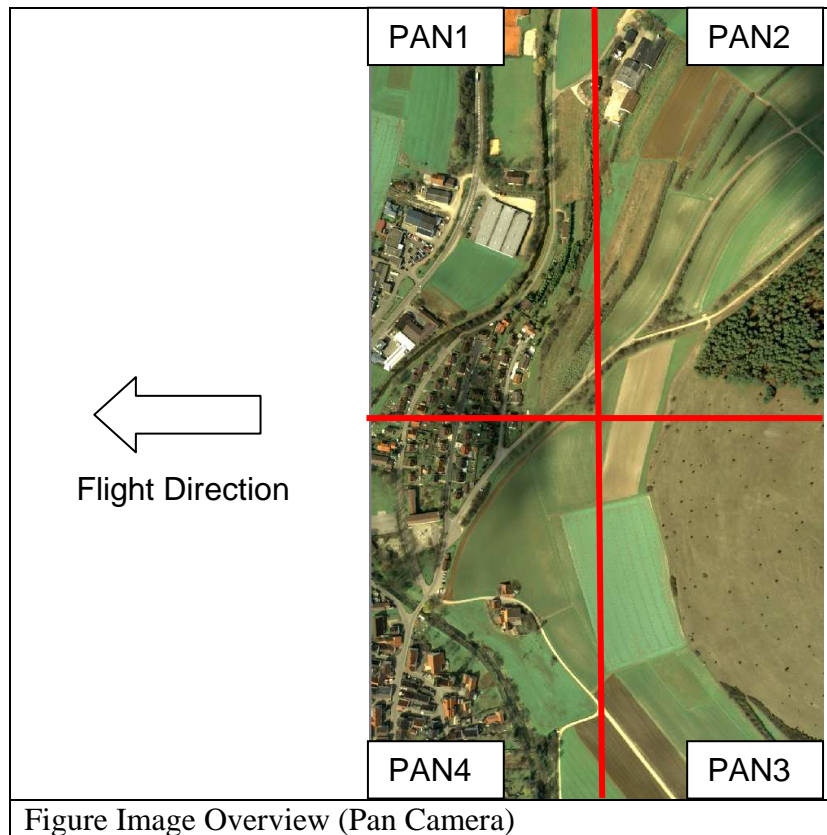


Figure Image Overview (Pan Camera)

### **Camera Parameter for Virtual Image (High Resolution)**

Virtual Focal Length [m]	0.12
Virtual Sensor Size [Pixel]	13824 x 7680
Virtual Pixel Size [ $\mu\text{m}$ ]	12
Virtual Principle Point [mm]	X = 0.0 Y = 0.0
Distortion Parameter	Distortion Free

### **Camera Parameter for Virtual Image (Color Resolution) before Version PPS 5.0.10.3**

Virtual Focal Length [m]	0.12 / 4.75
Virtual Sensor Size [Pixel]	3072 x 2048
Virtual Pixel Size [ $\mu\text{m}$ ]	12
Virtual Principle Point [mm]	X= -0.646 Y=0.646
Distortion Parameter	Distortion Free



Calibration Protocol  
DMC01 - 0050



**Camera Parameter for Virtual Image (Color Resolution) after  
Version PPS 5.1.10.3**

Virtual Focal Length [m]	0.030
Virtual Sensor Size [Pixel]	3456x1920
Virtual Pixel Size [ $\mu\text{m}$ ]	12
Virtual Principle Point [mm]	X = 0.0 Y = 0.0
Distortion Parameter	Distortion Free



Calibration Protocol  
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### Camera Serial Number and Burn-In flights

	Burn In Flight: 13.04.2010					
Camera	Serial Number	Calib. Date				
PAN1	00115781	17.10.2008				
PAN2	00115783	17.10.2008				
PAN3	00115784	18.10.2008				
PAN4	00115786	18.10.2008				
MS1 (NIR)	00114326	16.10.2008				
MS2 (Blue)	00114331	16.10.2008				
MS3 (Red)	00114327	15.10.2008				
MS4 (Green)	00114330	16.10.2008				

## Camera Orientation PAN-Cameras (Burn-In Flight 13.04.2010)

Camera (Serial Number)	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
PAN1 (00115781)	0.064 (0)	-0.079 (0)	1000 (0)	18.004964 (0.001)	10.079045 (0.001)	86.691993 (0.001)
PAN2 (00115783)	-0.064 (0)	-0.079 (0)	1000 (0)	17.922302 (0.001)	-10.213032 (0.001)	93.325800 (0.001)
PAN3 (00115784)	-0.064 (0)	0.079 (0)	1000 (0)	-17.994692 (0.001)	-10.082768 (0.001)	-93.566806 (0.001)
PAN4 (00115786)	0.064 (0)	0.079 (0)	1000 (0)	-17.932943 (0.001)	10.215581 (0.001)	-86.680261 (0.001)


The data is connected to the virtual projection center of the virtual image.

The above Platform calibration values are initial values and are liable to slight fluctuations between project images and between different projects. The position is fix and error free. The rotation axes of the angles are (in this order)

Omega	x-Axis
Phi	y-Axis
Kappa	z-Axis

The results of the Platform calibration were generated with DMC Postprocessing SW (PPS), Version 6.1, from Intergraph Z/I Imaging photogrammetric product suite.

Platform calibration performed by

  
Dipl. Ing. C. Müller

29.04.2010  
Date

## Aerotriangulation Results (Burn-In Flight 13.04.2010)

	Photo Scale	1:5000
	Flying Height [m]	2000 AGL
	Flying Altitude [m]	2050 AMSL
	Run-Spacing [m]	1105.9
	Base-Length [m]	614.4
	Number of Exposures	40
	Side-lap [%]	60
	End-lap [%]	60
	Terrain Height [m]	50
	Number of strips	4
	Photos in one strip	4 x 10 W-E
	Photos Used	40
	Control Points Used	12
	Check Points Used	
GSD [cm]	20	

### Statistic results:

<b>Matching results:</b> 0 Weak Areas - covered with clouds	
<b>Whole Block</b>	40 exposures used 0 exposures not used
<b>Whole Block</b>	<b>Sigma relativ:</b> 2.707 um
<b>Whole Block</b>	<b>Sigma absolut:</b> 2.722 um
<b>Whole Block</b>	
Photo-T Parameters and Results for Project 10imu2000ss50	
PhotoT Triangulation Options	
Adjustment Mode	: Absolute
Precision Computation	: Enabled
Error Detection	: Enabled
Camera Calibration	: Disabled
Self-Calibration	: Disabled
Given EO/GPS	: Enabled
Antenna Offsets	: Disabled
GPS Shift/Drift Correction	: Enabled
INS Shift/Drift Correction	: Enabled
Parameters	
	Parameter X/Omega Y/Phi Z/Kappa XY
	RMS Control 0.083 0.089 0.067 0.086
	RMS Check
	RMS Limits 0.100 0.100 0.150
	Max Ground Residual 0.129 0.215 0.117
	Residual Limits 0.200 0.200 0.200
	Mean Std Dev Object 0.056 0.062 0.132
	RMS Photo Position 0.022 0.029 0.040
	RMS Photo Attitude 0.001 0.001 0.001



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Mean Std Dev Photo Position	0.091	0.119	0.108
Mean Std Dev Photo Attitude	0.003	0.002	0.001

## Key Statistics

Sigma:            **2.7 um**  
Number of iterations: 9  
Degrees of Freedom: 9177

The results of the Aerotriangulation were generated with ImageStation Automatic Triangulation (ISAT), Version 6.1, from Intergraph Z/I Imaging photogrammetric product suite.

Aerotriangulation performed by

  
Dipl. Ing. C. Müller

29.04.2010  
Date





Calibration Protocol  
DMC01 - 0050



## Calibration Certificate

N<sup>o</sup> 00115781

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115781

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66


Date of Calibration                      17.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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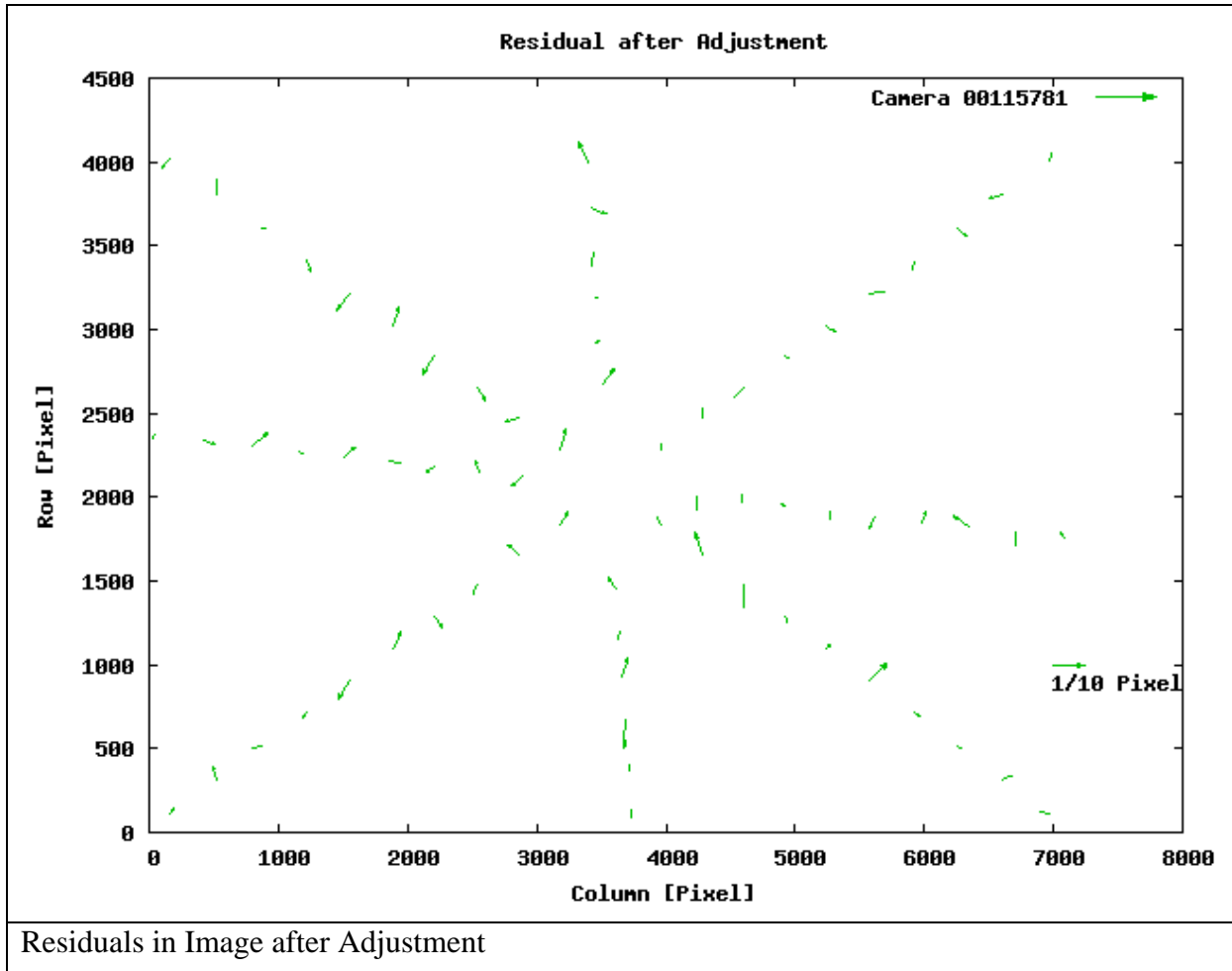
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115781

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001726	6.47E-06
	$y_0$	-0.0001801	3.931E-06
Focal Length [m]	$\Delta f$	-0.0004179	1.132E-06
Radial Distortion	$K_1$	0.7559	0.02906
	$K_2$	-334.1	26.15
	$K_3$	-15900	6879
Decentering distortion	$P_1$	-0.0004065	0.0001474
	$P_2$	0.0004353	7.471E-05
In Plane Distortion	$B_1$	-4.237E-05	7.504E-06
	$B_2$	1.054E-05	4.306E-06

Adjusted Focal length = 0.12+ dc =0.1195821 [m]



Max Residual [ $\mu\text{m}$ ]: 0.8

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

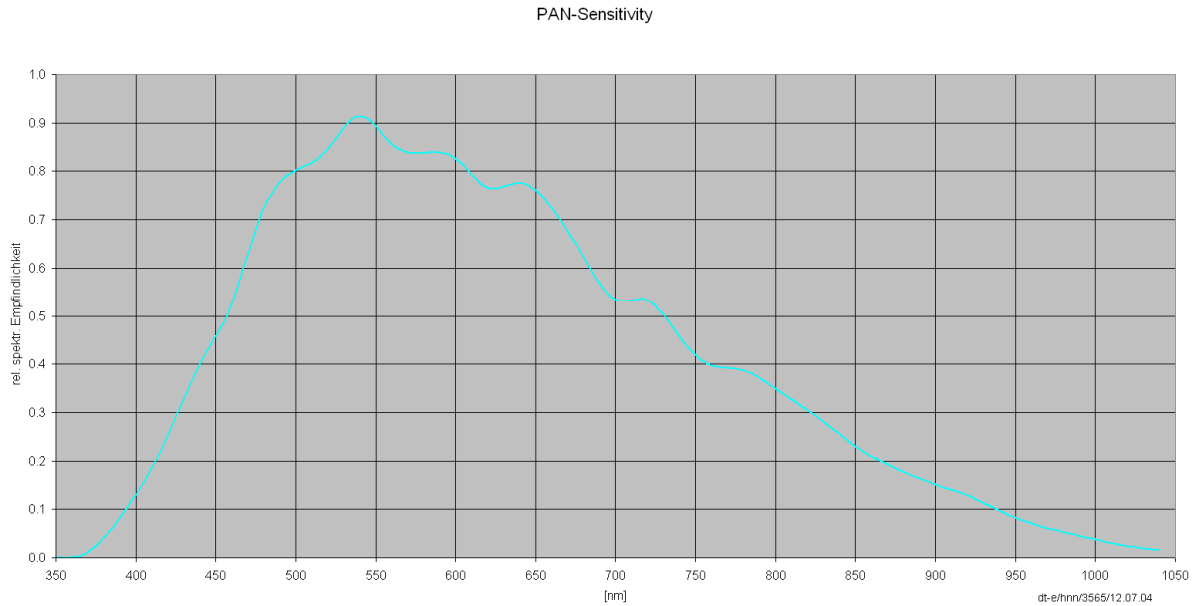
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00115781
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

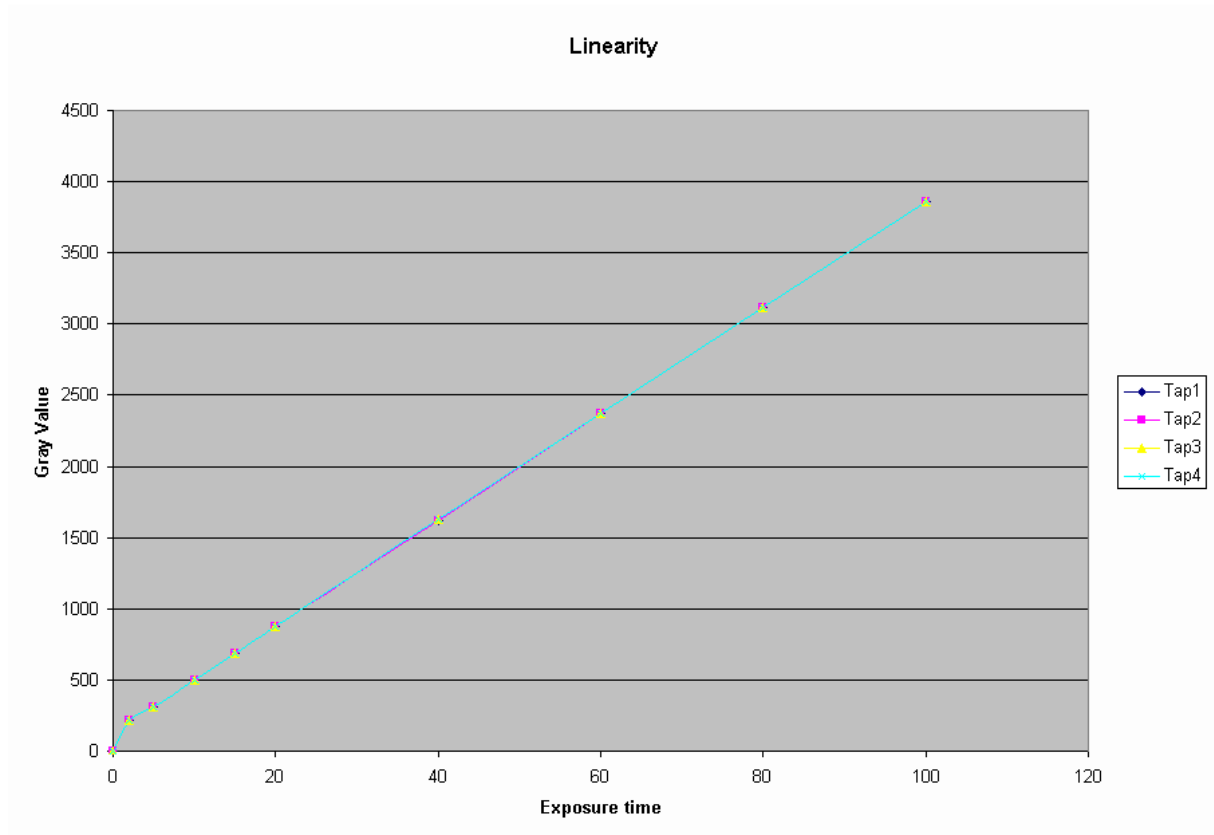
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

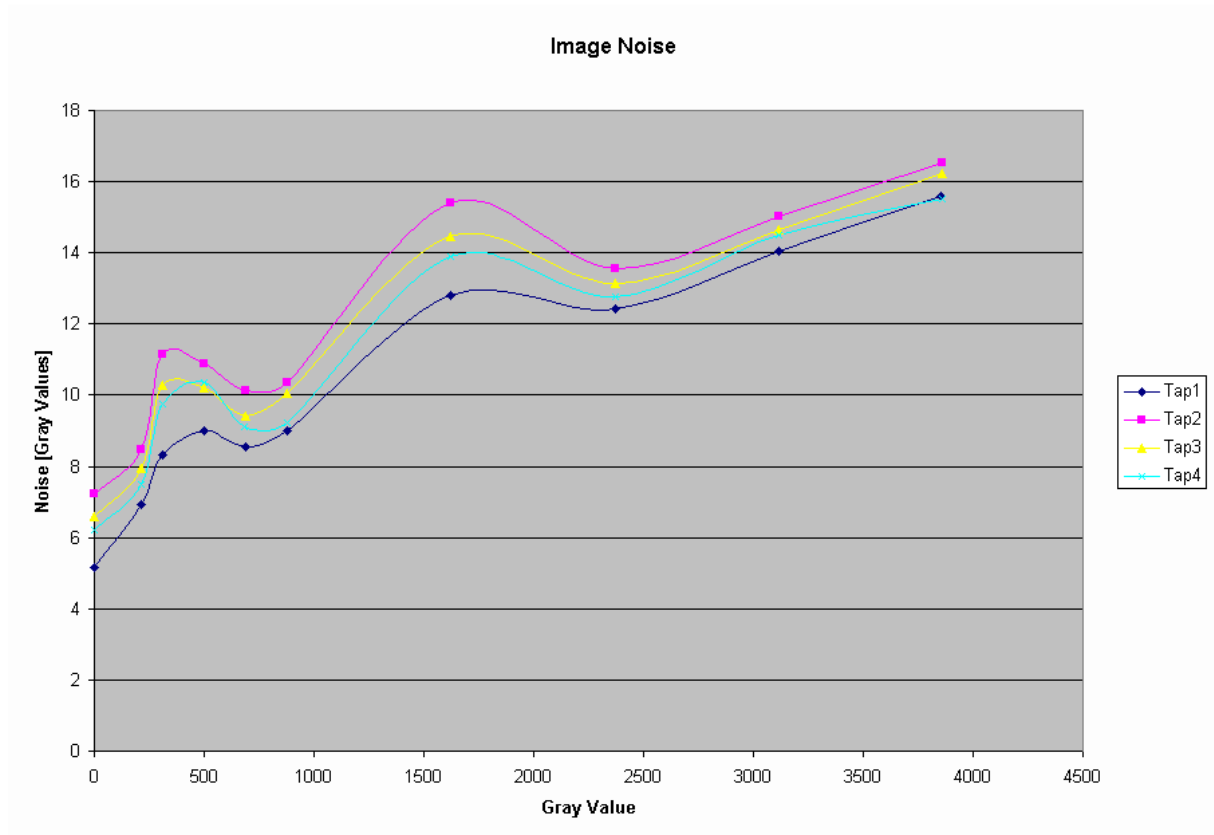
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

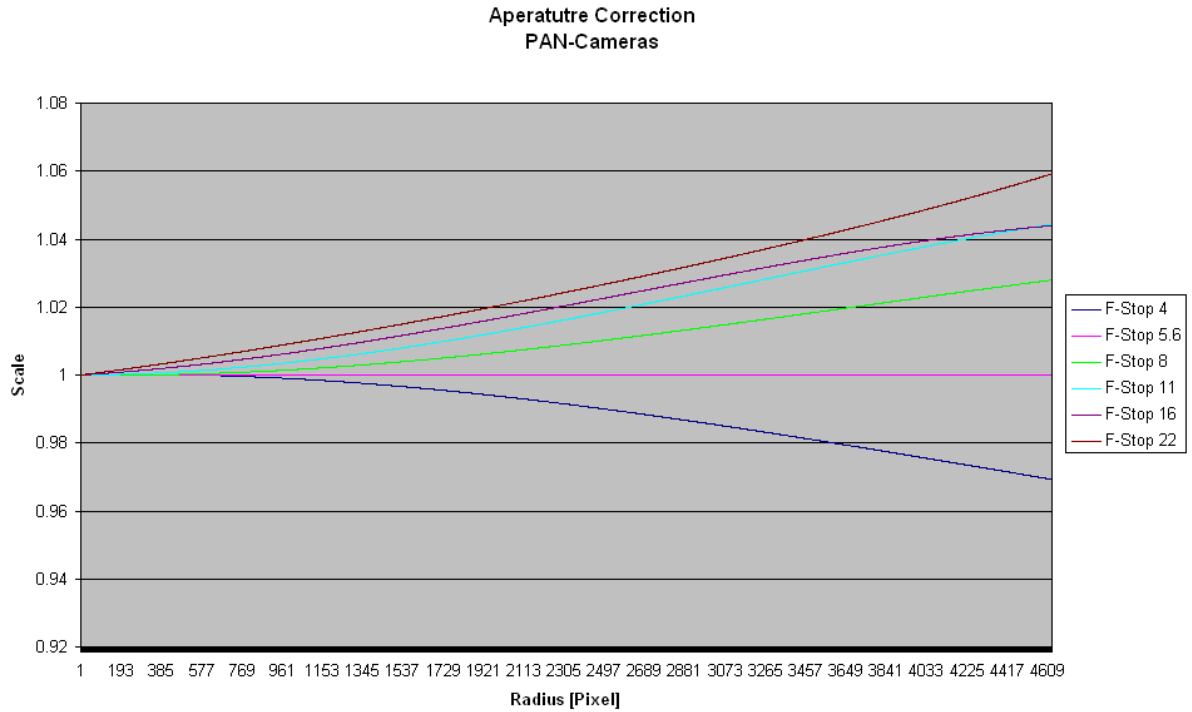
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

## Aperture Correction



**Remark:**

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

## Defect Pixel List

Number of defect pixels: 6  
 Number of defect clusters: 0  
 Number of defect columns: 1

Nr	Row	Column
0	656	5825
1	657	5825
2	658	5825
3	656	5826
4	657	5826
5	658	5826



# Calibration Protocol DMC01 - 0050



Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
0	802	3768	2047	3768

## Remark

See Appendix for definition of defect pixels and maximal allowed numbers.





Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00115783**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115783

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66


Date of Calibration                      17.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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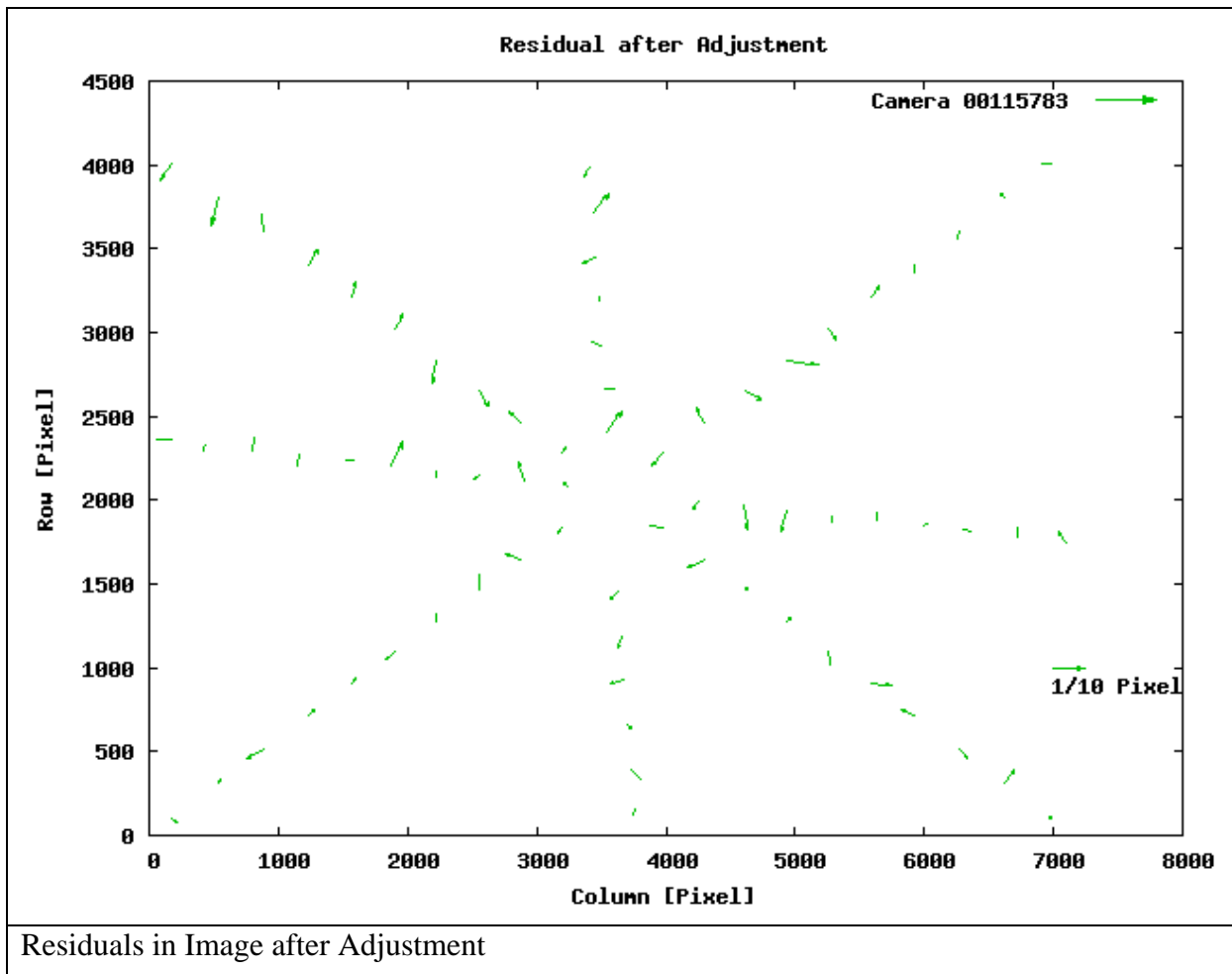
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115783

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-3.136E-05	6.98E-06
	$y_0$	-0.0001329	4.224E-06
Focal Length [m]	$\Delta f$	-0.0003981	1.218E-06
Radial Distortion	$K_1$	0.8984	0.03129
	$K_2$	-360	28.19
	$K_3$	-14890	7425
Decentering distortion	$P_1$	-0.0002196	0.0001591
	$P_2$	-0.0002733	8.011E-05
In Plane Distortion	$B_1$	5.688E-05	8.125E-06
	$B_2$	-3.291E-06	4.671E-06

Adjusted Focal length = 0.12+ dc =0.1196019 [m]



Max Residual [ $\mu\text{m}$ ]: 1.2

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

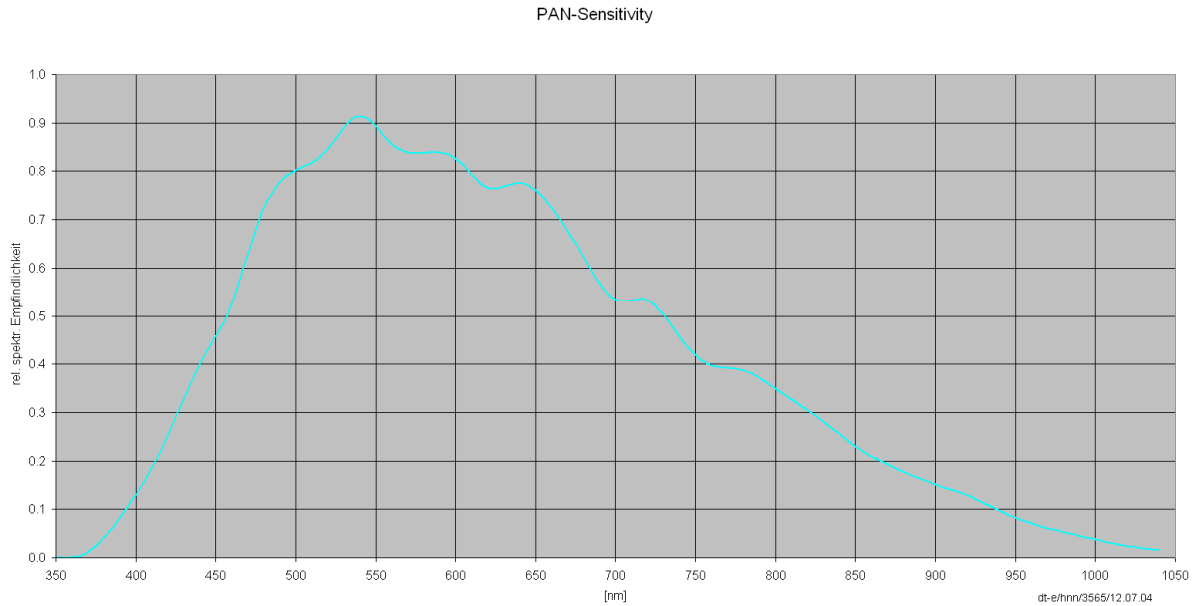
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00115783
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

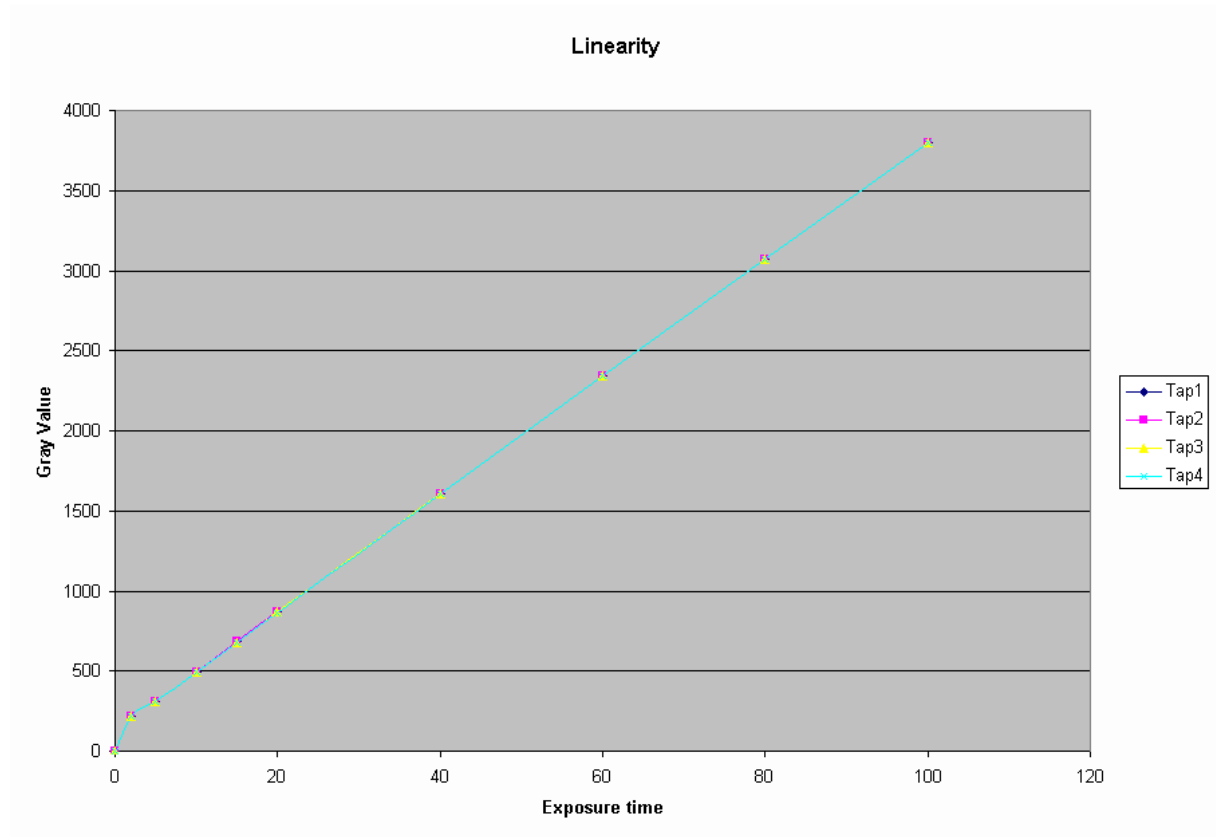
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

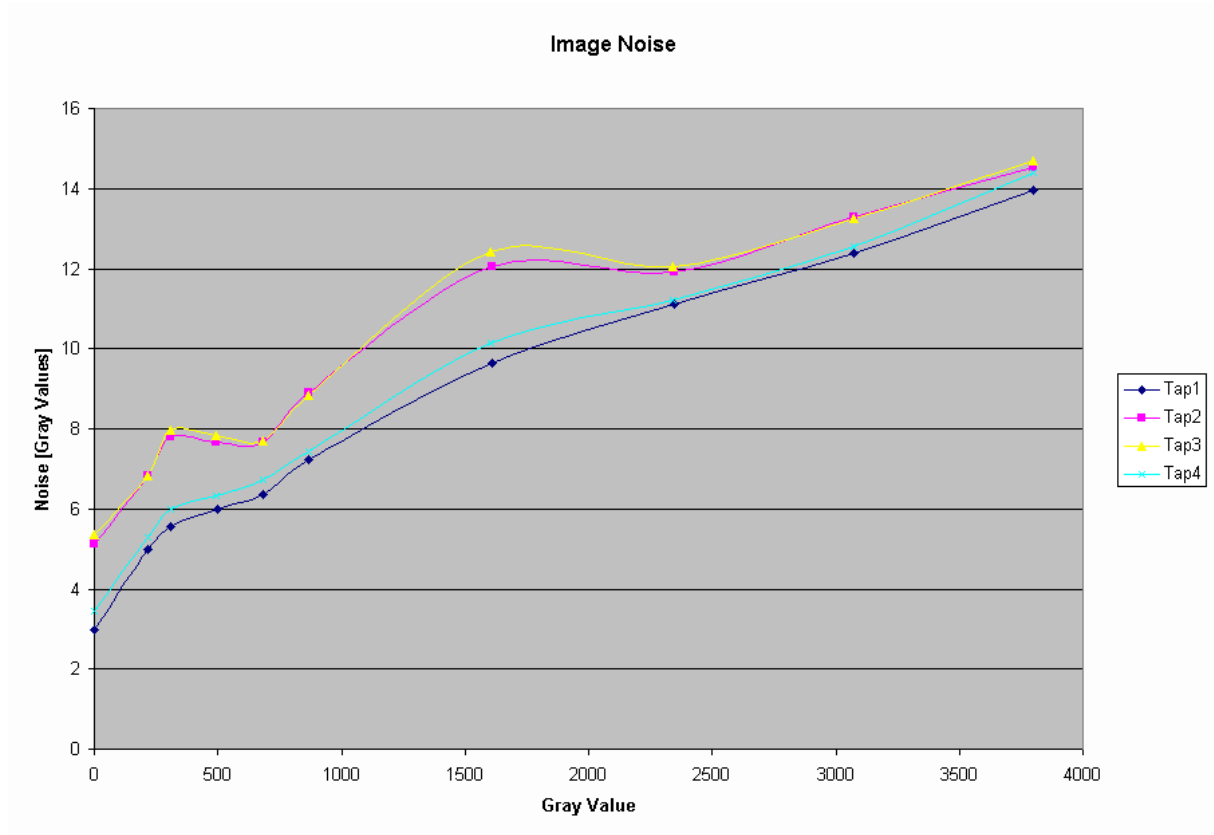
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

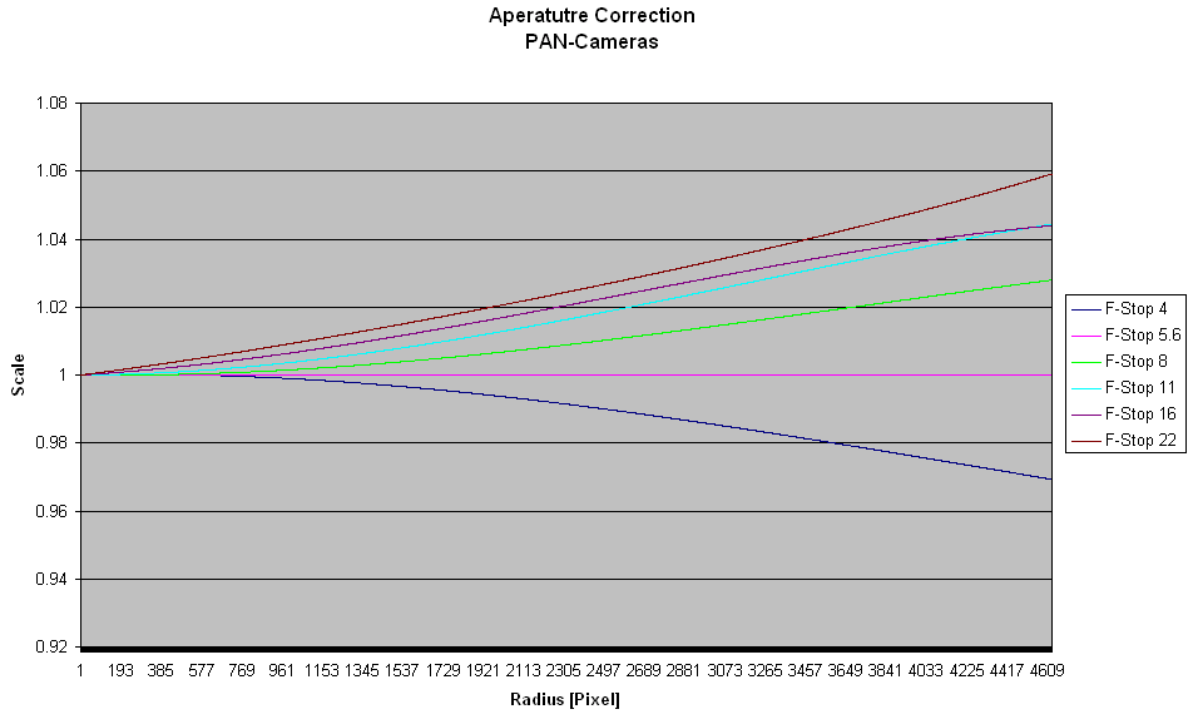
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

## Aperture Correction



Remark:

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

## Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00115784**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-Panchromatic  
Serial Number            00115784

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66

Date of Calibration                      18.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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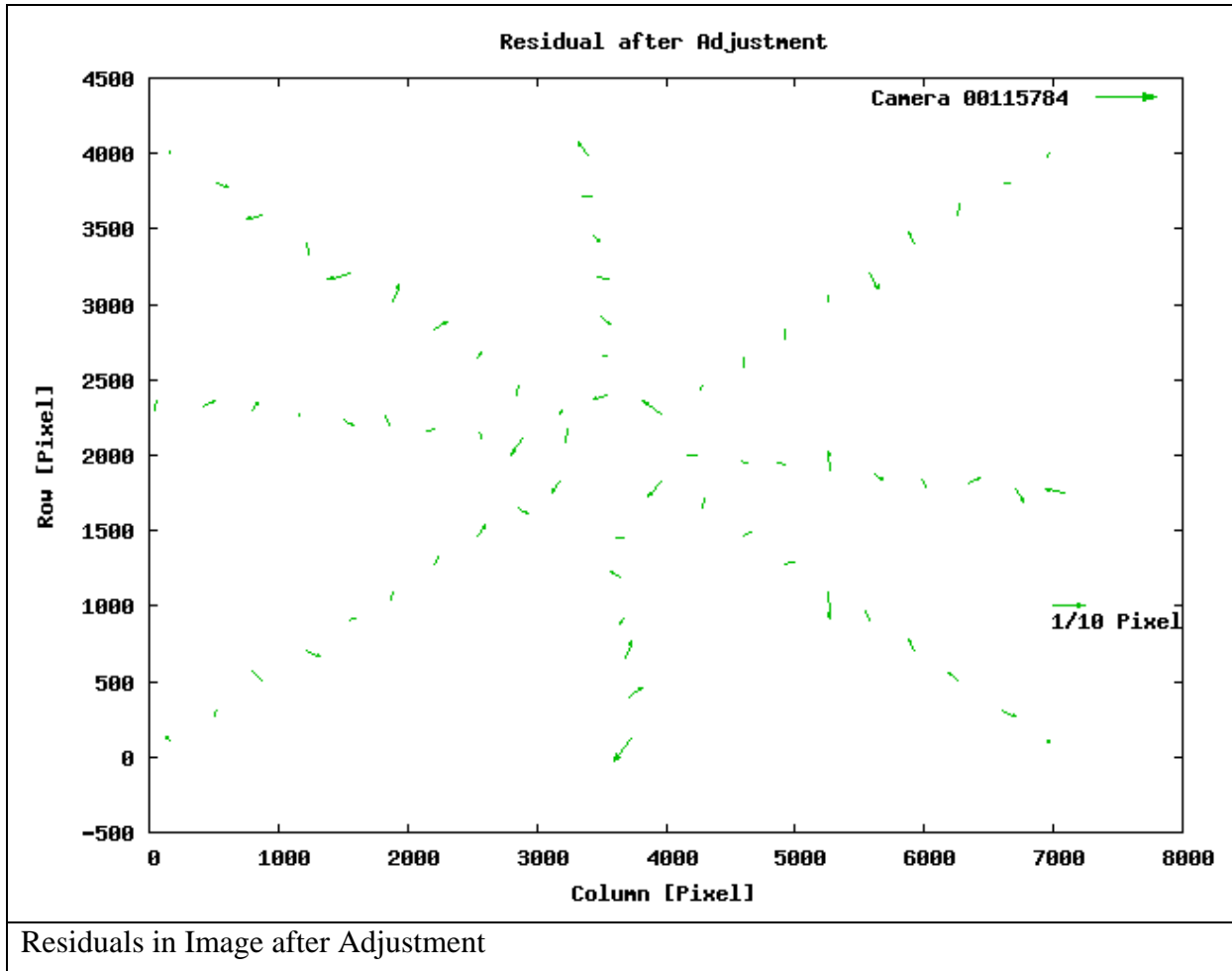
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115784

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001909	6.52E-06
	$y_0$	-7.56E-05	3.945E-06
Focal Length [m]	$\Delta f$	-0.0004467	1.138E-06
Radial Distortion	$K_1$	0.7888	0.02923
	$K_2$	-330.8	26.33
	$K_3$	-15790	6935
Decentering distortion	$P_1$	-0.0003364	0.0001486
	$P_2$	-4.314E-05	7.482E-05
In Plane Distortion	$B_1$	-1.864E-05	7.589E-06
	$B_2$	2.988E-05	4.363E-06

Adjusted Focal length = 0.12+ dc =0.1195533 [m]



Max Residual [ $\mu\text{m}$ ]: 1.0

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

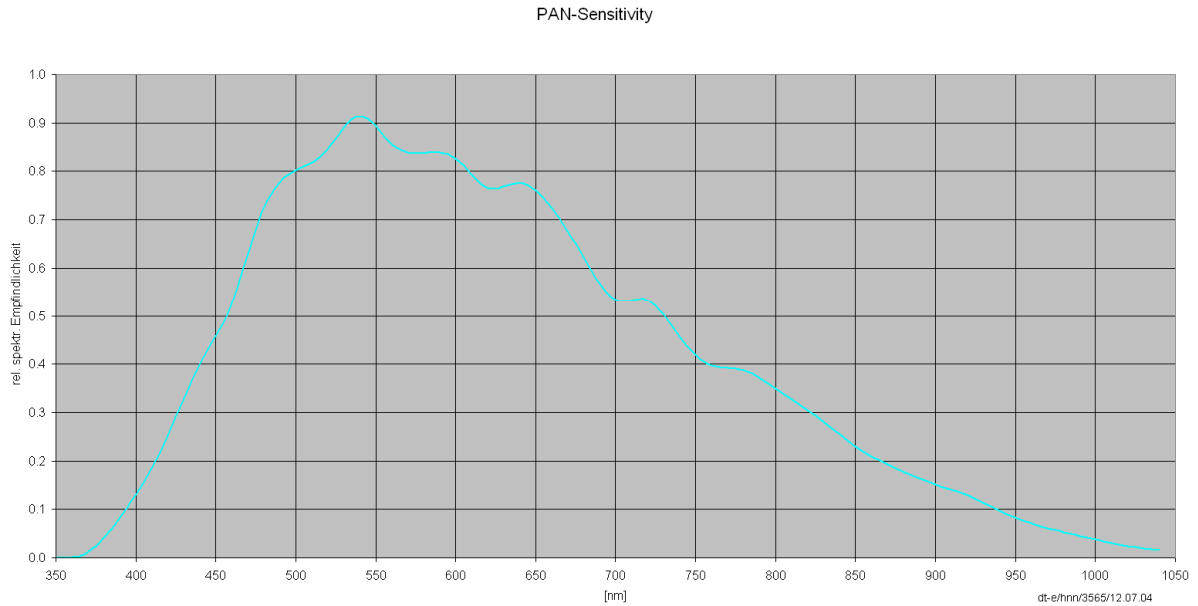
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00115784
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

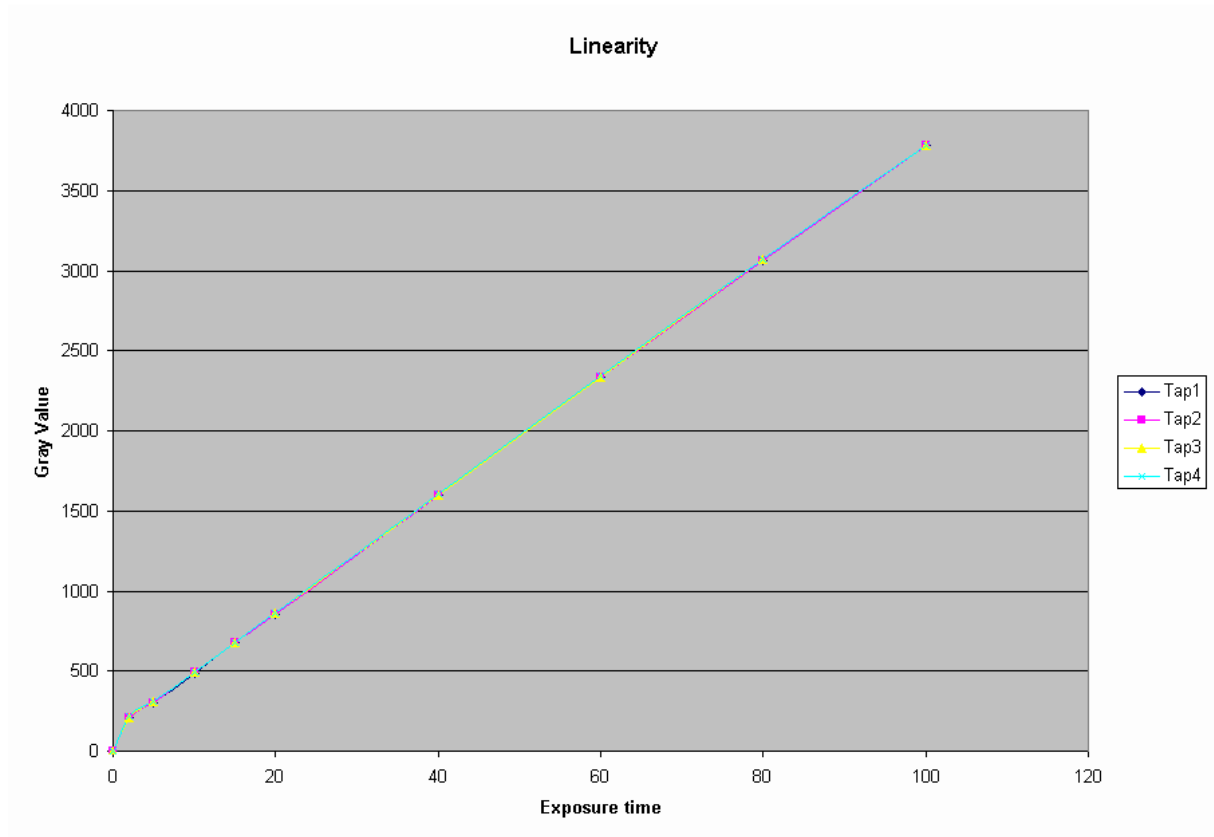
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

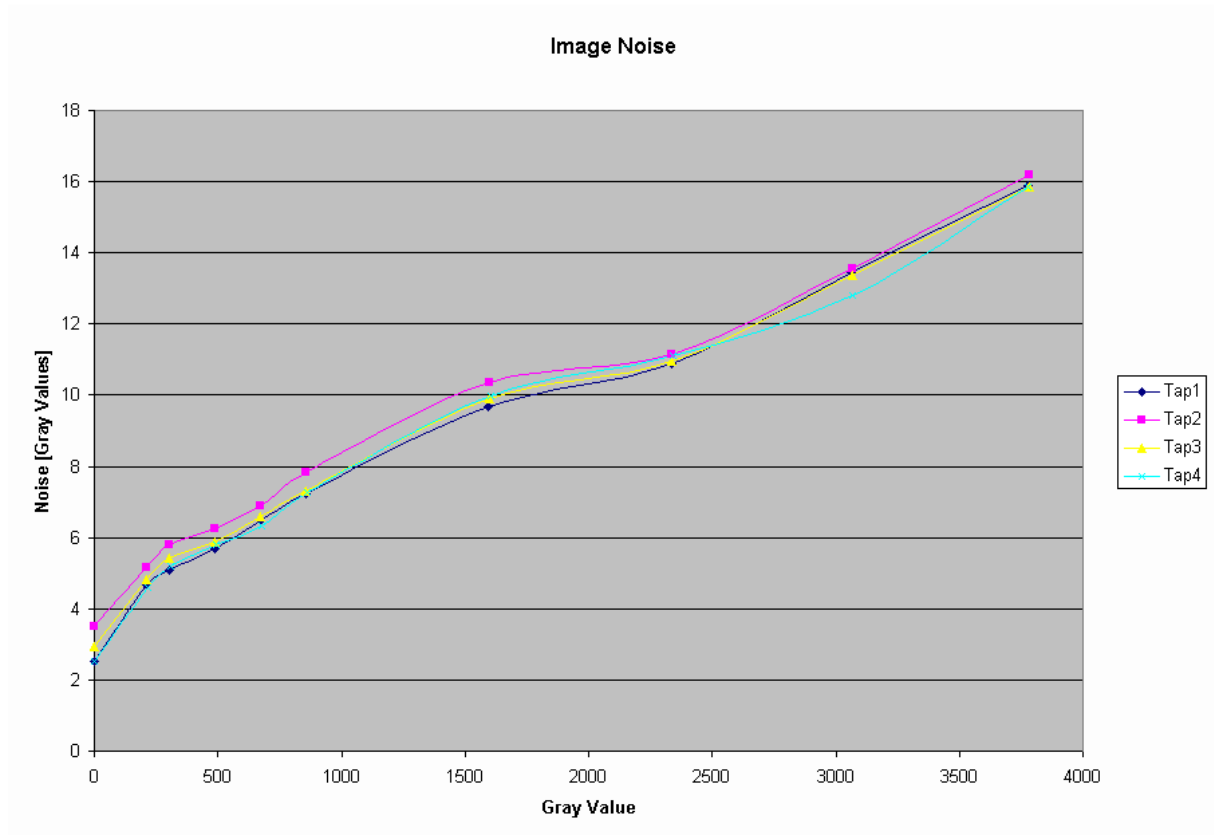
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

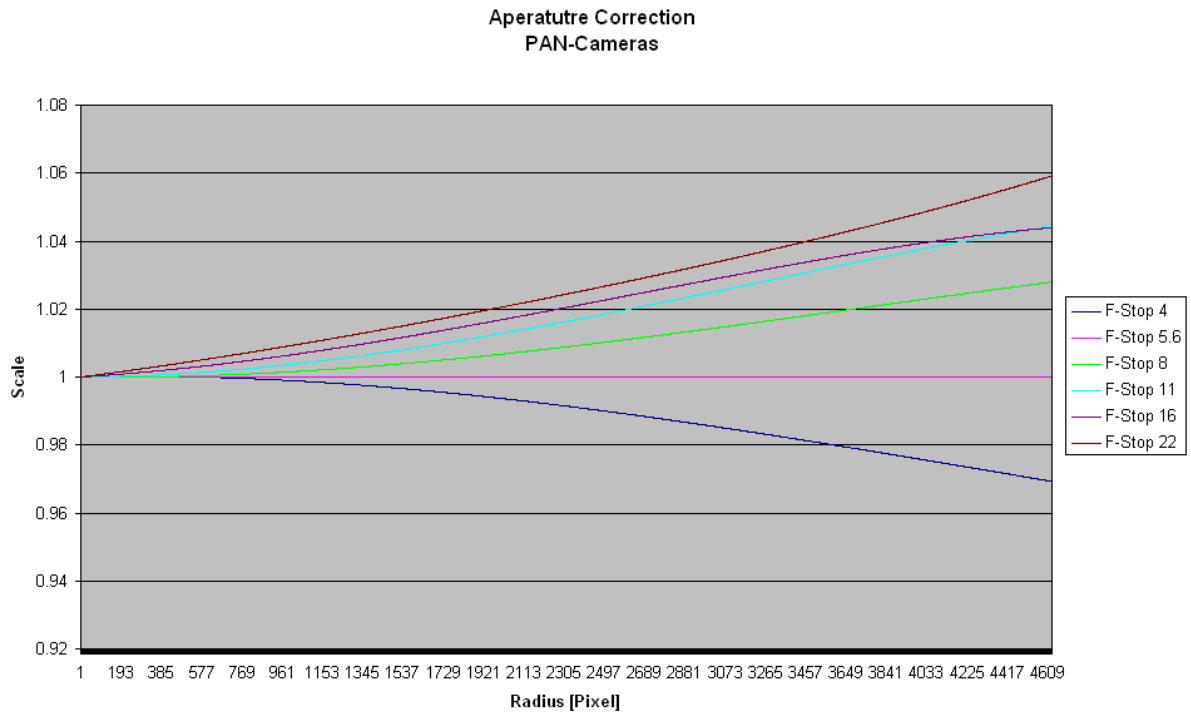
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

## Aperture Correction



Remark:

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

## Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00115786**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115786

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66

Date of Calibration                      18.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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## Geometric Calibration Protocol

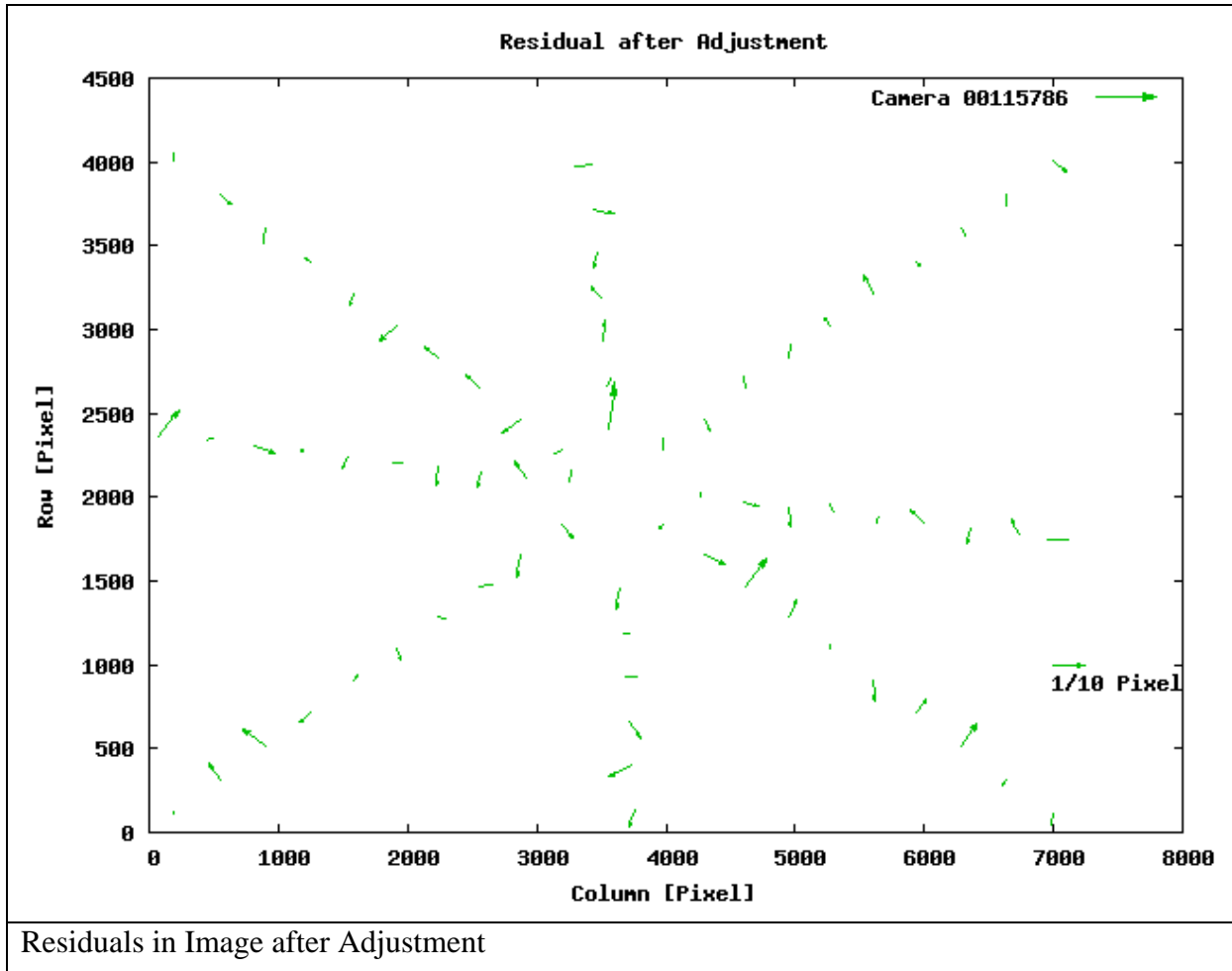
### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115786

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	0.0001045	8.134E-06
	$y_0$	-0.000177	4.922E-06
Focal Length [m]	$\Delta f$	-0.0004622	1.419E-06
Radial Distortion	$K_1$	0.88	0.03646
	$K_2$	-294.4	32.85
	$K_3$	-32770	8653
Decentering distortion	$P_1$	-0.0001355	0.0001854
	$P_2$	-0.0004618	9.335E-05
In Plane Distortion	$B_1$	1.907E-05	9.468E-06
	$B_2$	7.762E-05	5.443E-06

Adjusted Focal length = 0.12+ dc =0.1195378 [m]





Max Residual [ $\mu\text{m}$ ]: 1.4

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

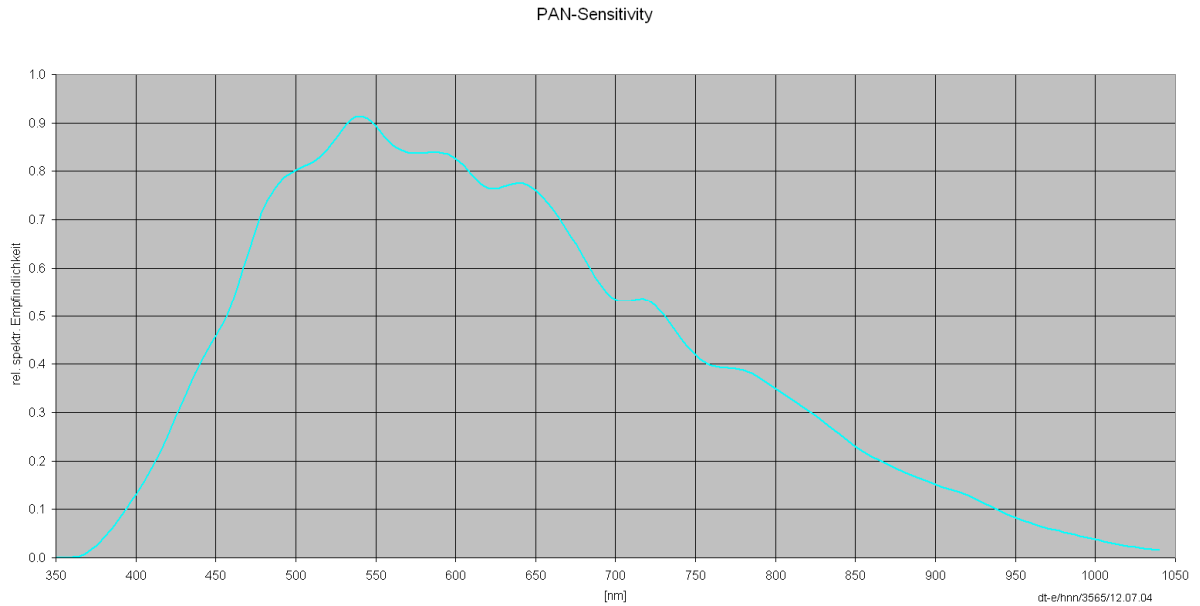
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00115786
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

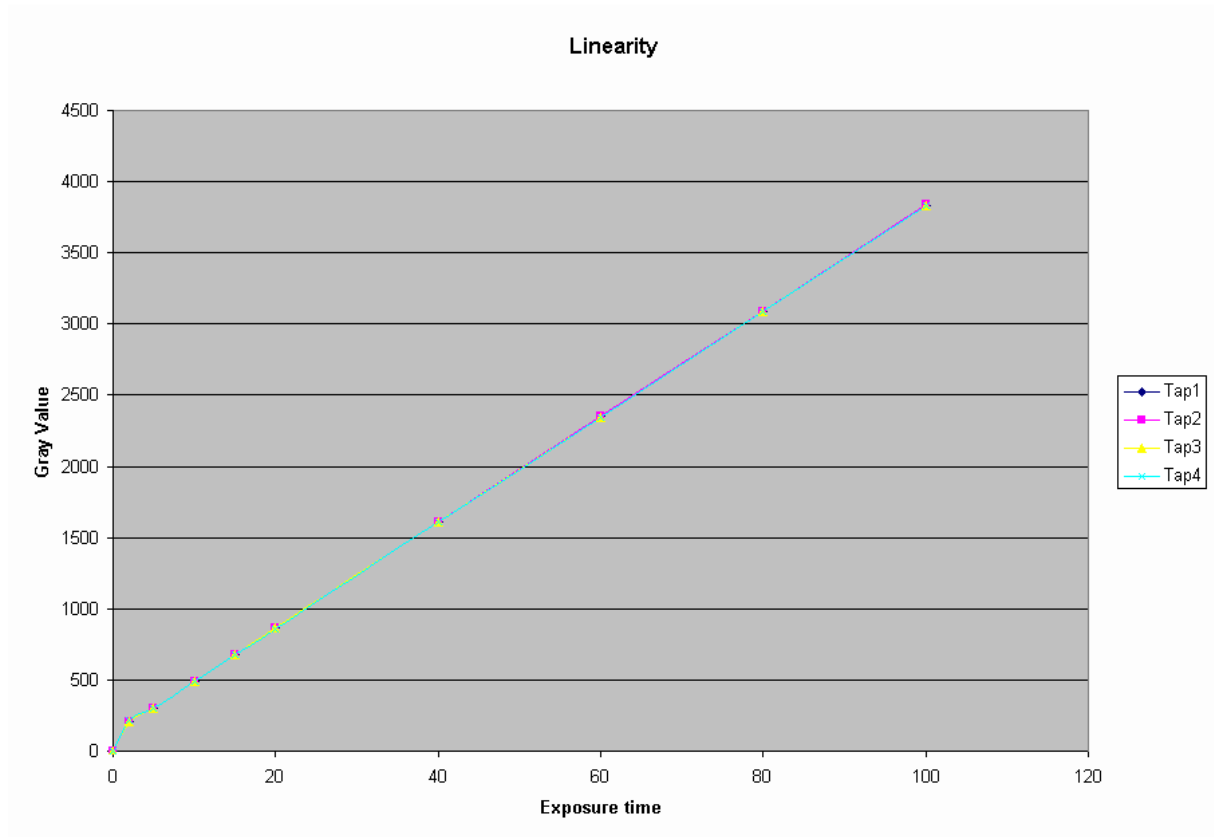
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

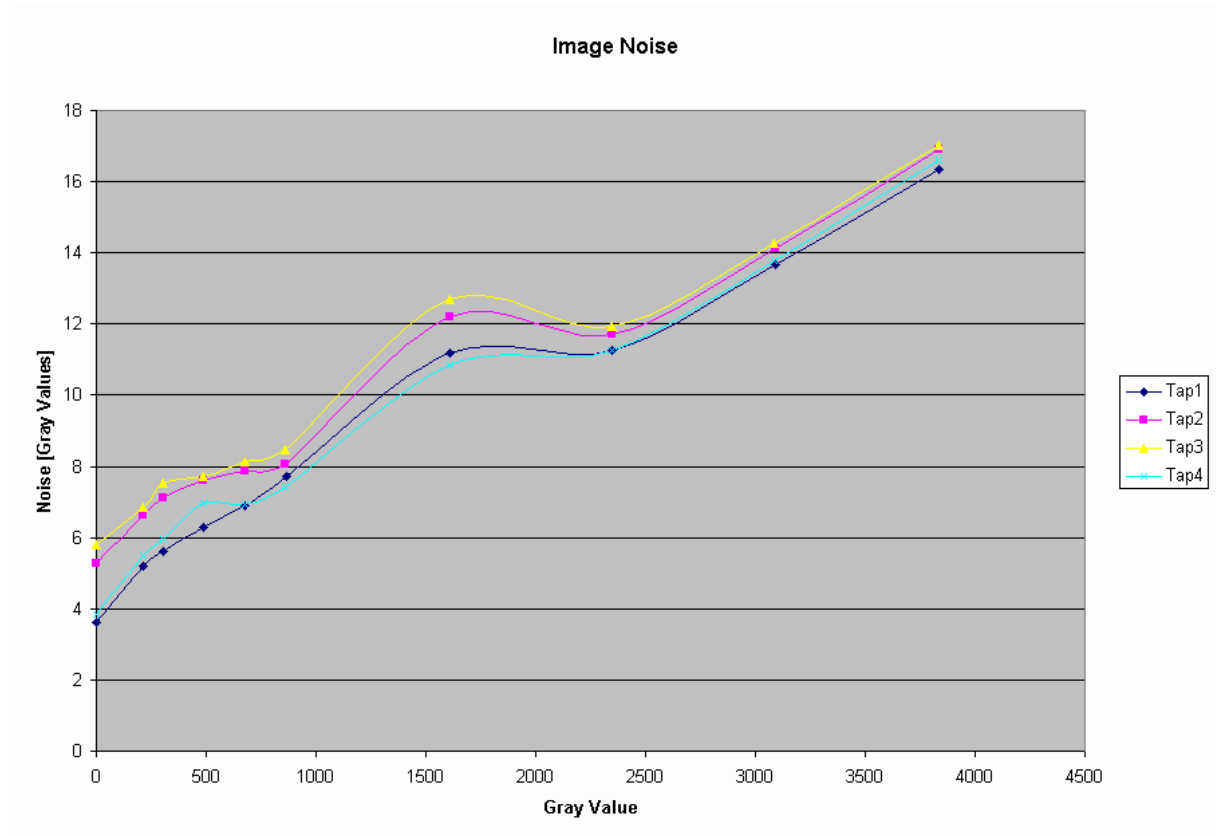
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

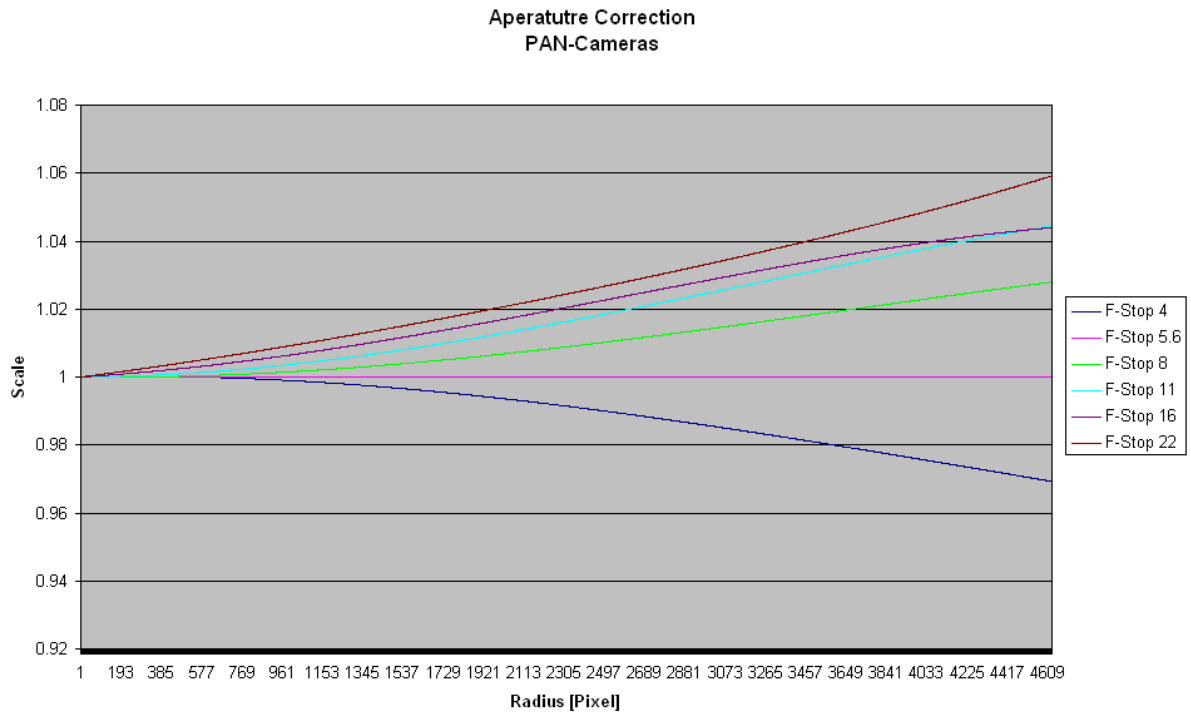
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

## Aperture Correction



Remark:

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

## Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00114326**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-NIR  
Serial Number            00114326

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66


Date of Calibration                      16.Okt.2008

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CertifiedDate


30.Apr.2010

Division Head



(H. Sohnle)

Person in Charge



(S. Schröder)

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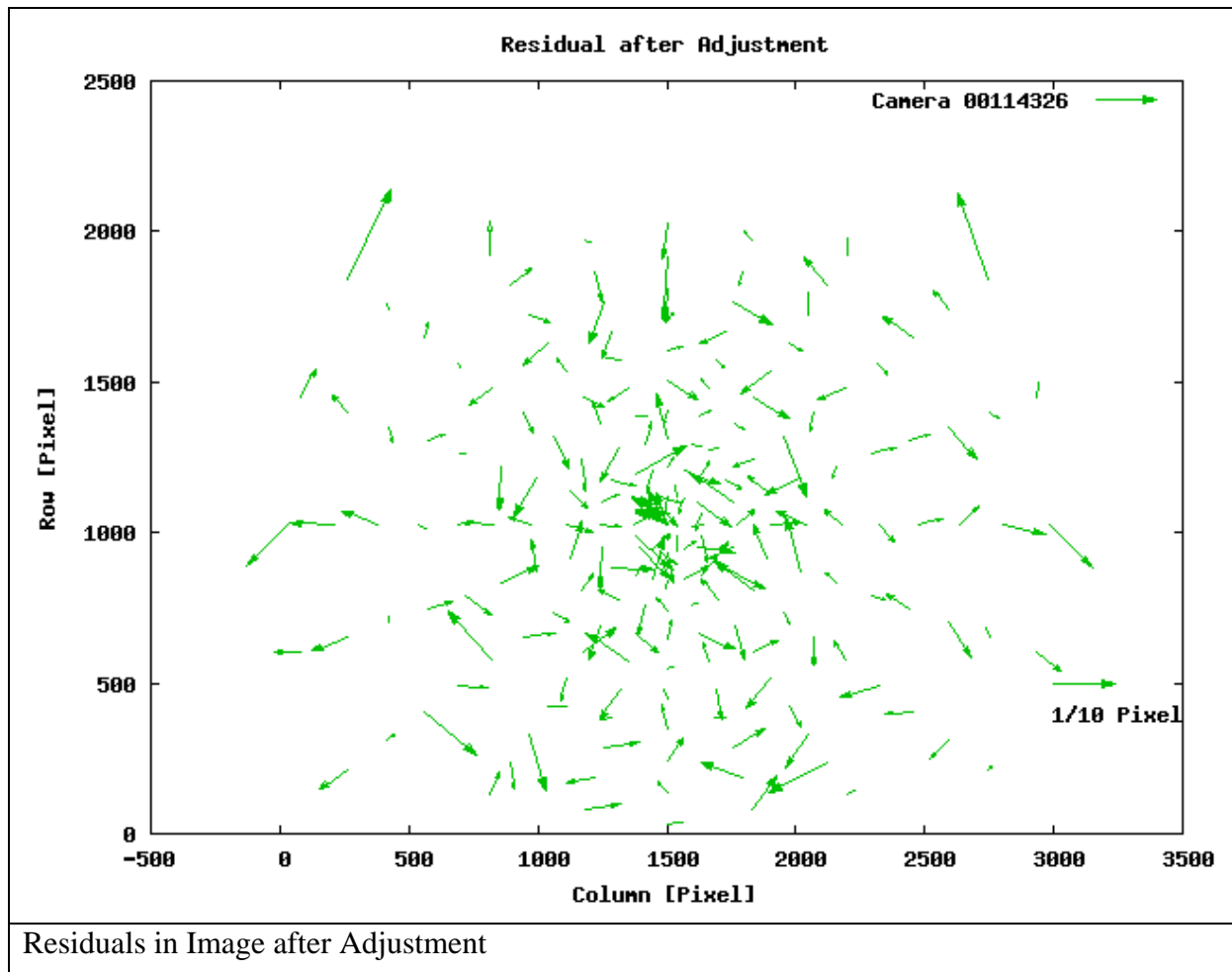
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00114326

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0003465	1.247E-06
	$y_0$	-4.953E-05	8.805E-07
Focal Length [m]	$\Delta f$	-2.9E-06	4.616E-07
Radial Distortion	$K_1$	-145.3	0.3881
	$K_2$	224000	2476
	$K_3$	-146800000	4458000
Decentering distortion	$P_1$	0.000371	0.0006484
	$P_2$	0.00133	0.0004024
In Plane Distortion	$B_1$	0.0001348	1.142E-05
	$B_2$	-2.813E-05	9.229E-06

Adjusted Focal length = 0.025+ dc =0.0249971 [m]



Max Residual [ $\mu\text{m}$ ]: 1.7

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

The calibration model is explained in the section "Calibration Model" at the end of this documentation.

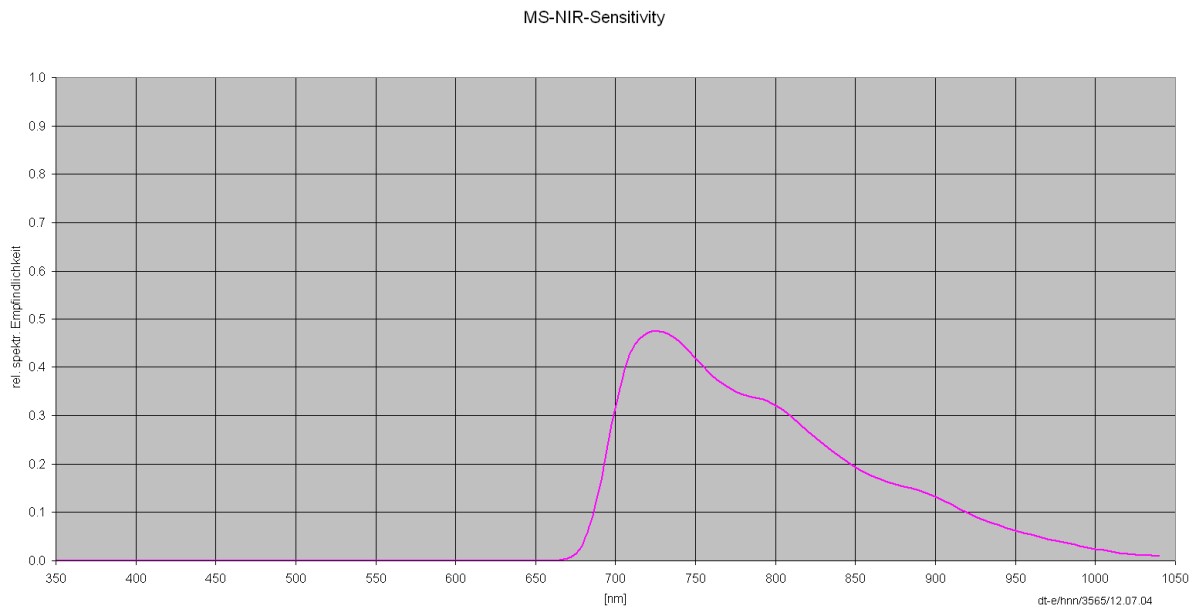
## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00114326
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1



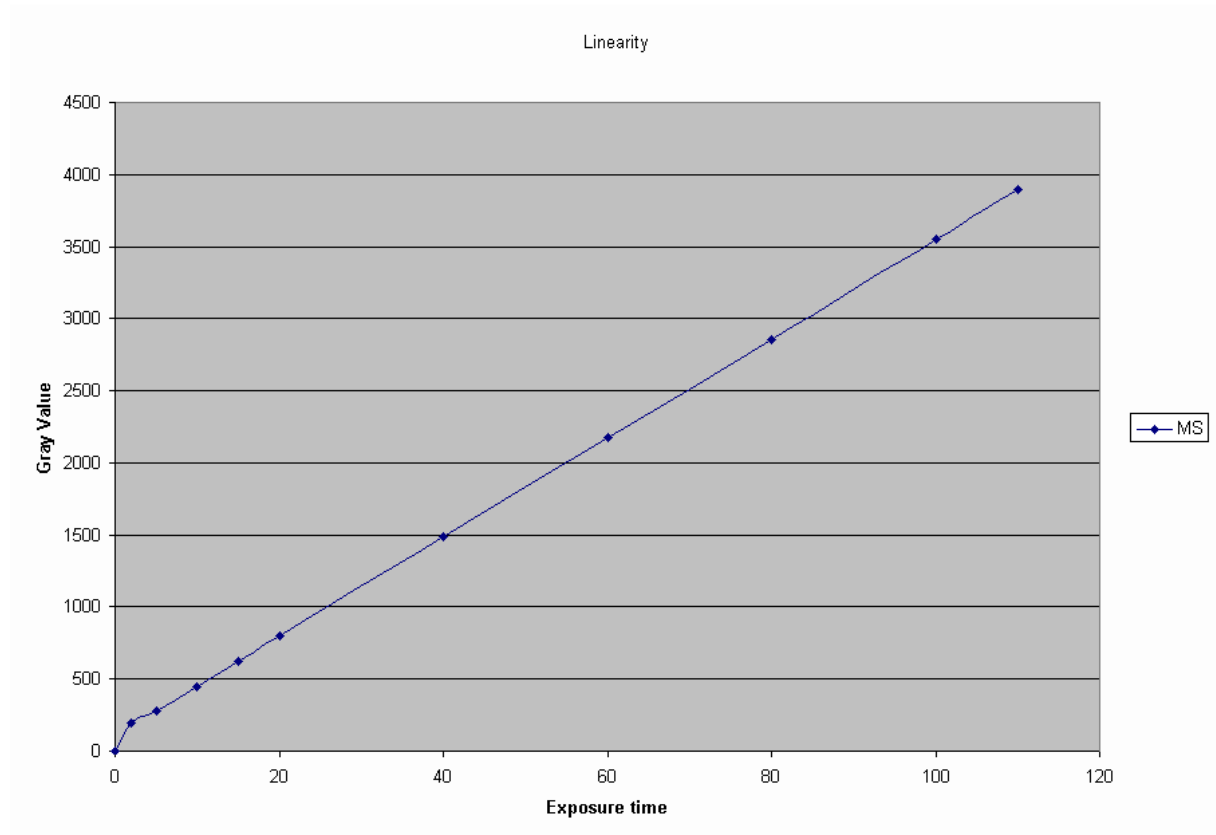
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

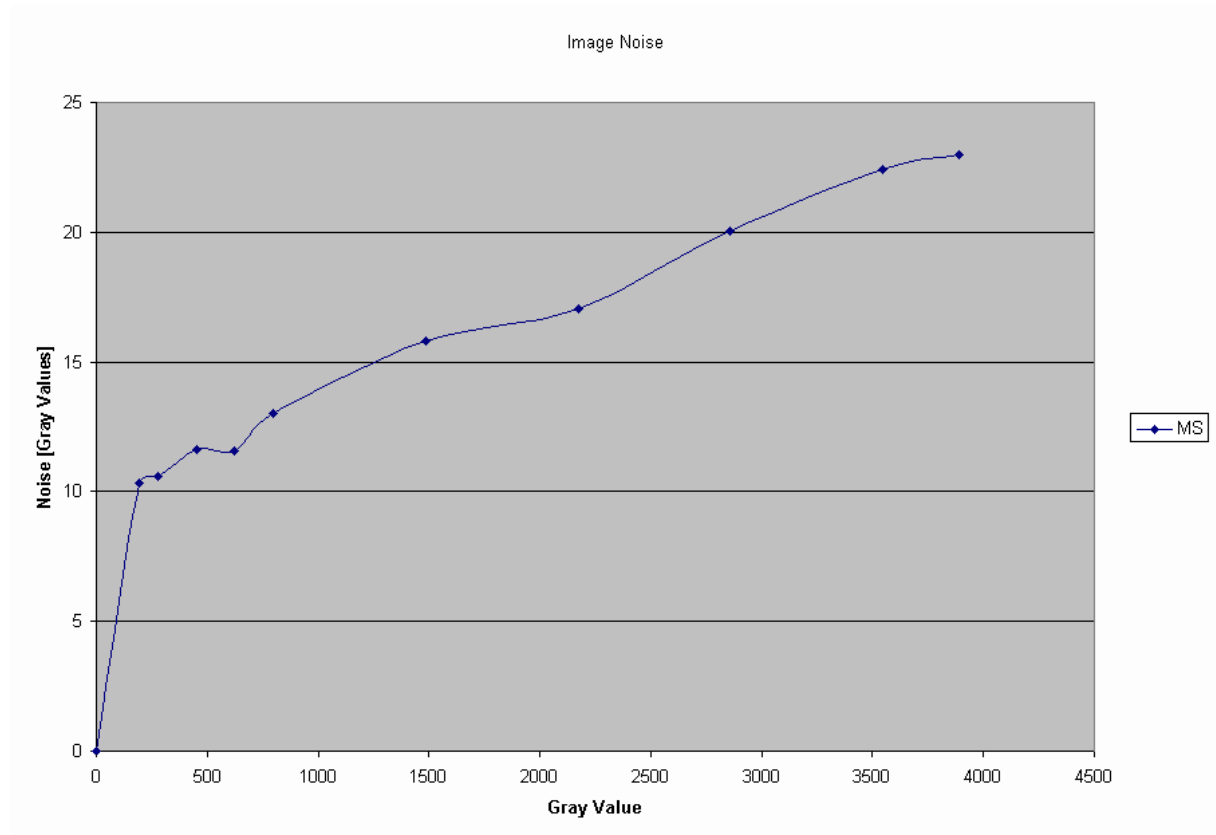
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

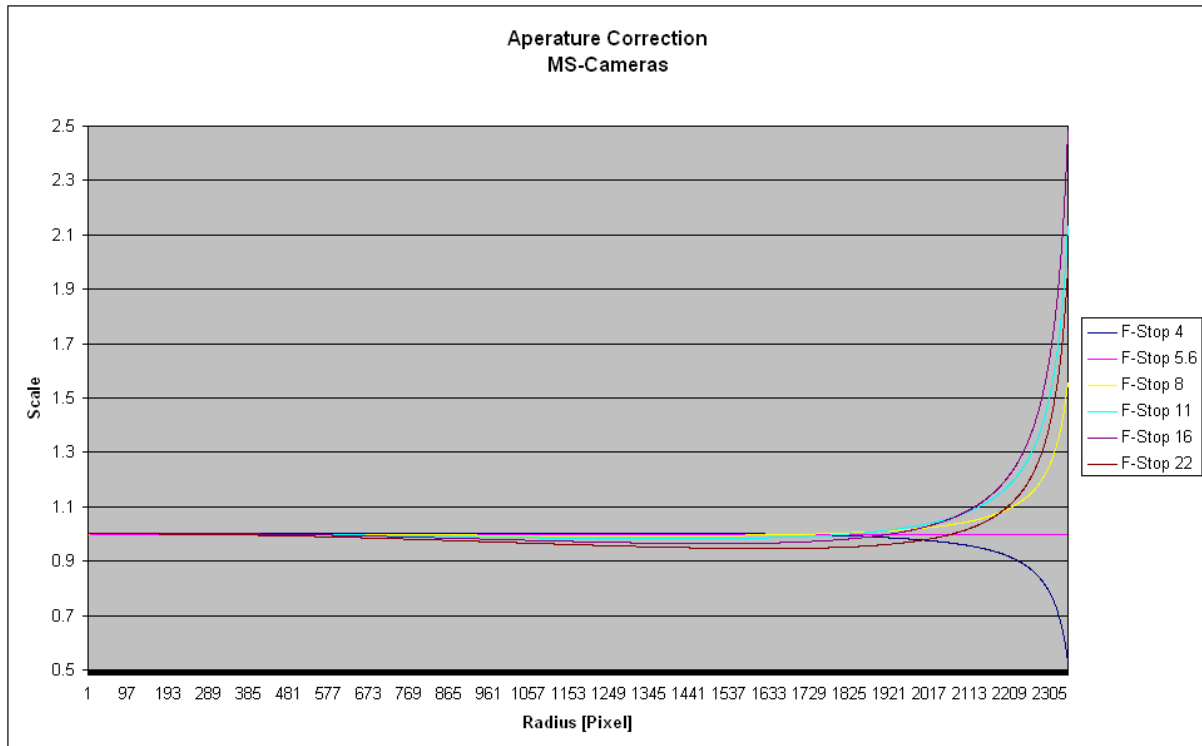
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

### Aperture Correction



**Remark:**

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

### Defect Pixel List

Number of defect pixels: 0  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr    Row    Column

Defect Column    RowStart    ColumnStart    RowEnd    ColumnEnd

**Remark**

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00114331**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Blue  
Serial Number            00114331

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66


Date of Calibration                      16.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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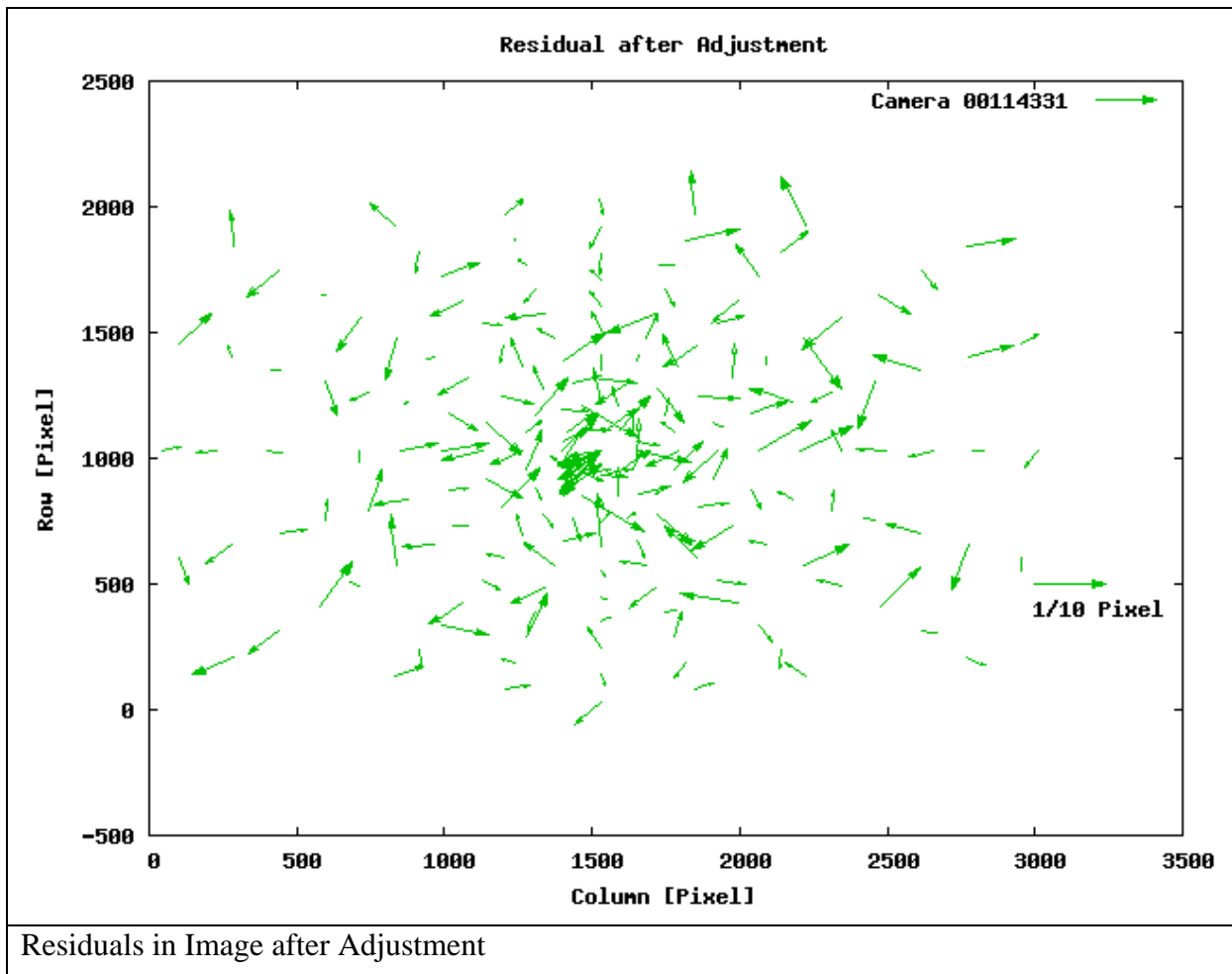
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00114331

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-9.705E-05	1.32E-06
	$y_0$	-6.78E-05	9.314E-07
Focal Length [m]	$\Delta f$	-3.298E-05	4.882E-07
Radial Distortion	$K_1$	-139	0.4105
	$K_2$	223600	2619
	$K_3$	-154200000	4713000
Decentering distortion	$P_1$	-0.001244	0.0006858
	$P_2$	-0.001277	0.0004257
In Plane Distortion	$B_1$	0.0001794	1.208E-05
	$B_2$	-1.45E-05	9.763E-06

Adjusted Focal length = 0.025+ dc =0.02496702 [m]



Max Residual [ $\mu\text{m}$ ]: 1.3

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

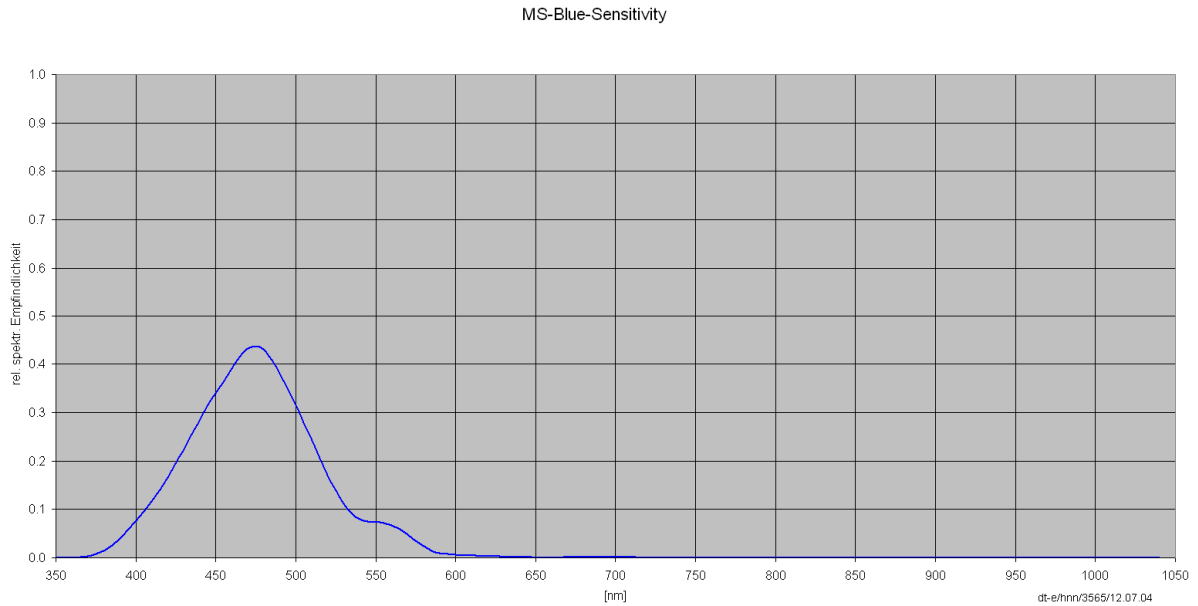
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00114331
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

## Sensitivity of camera

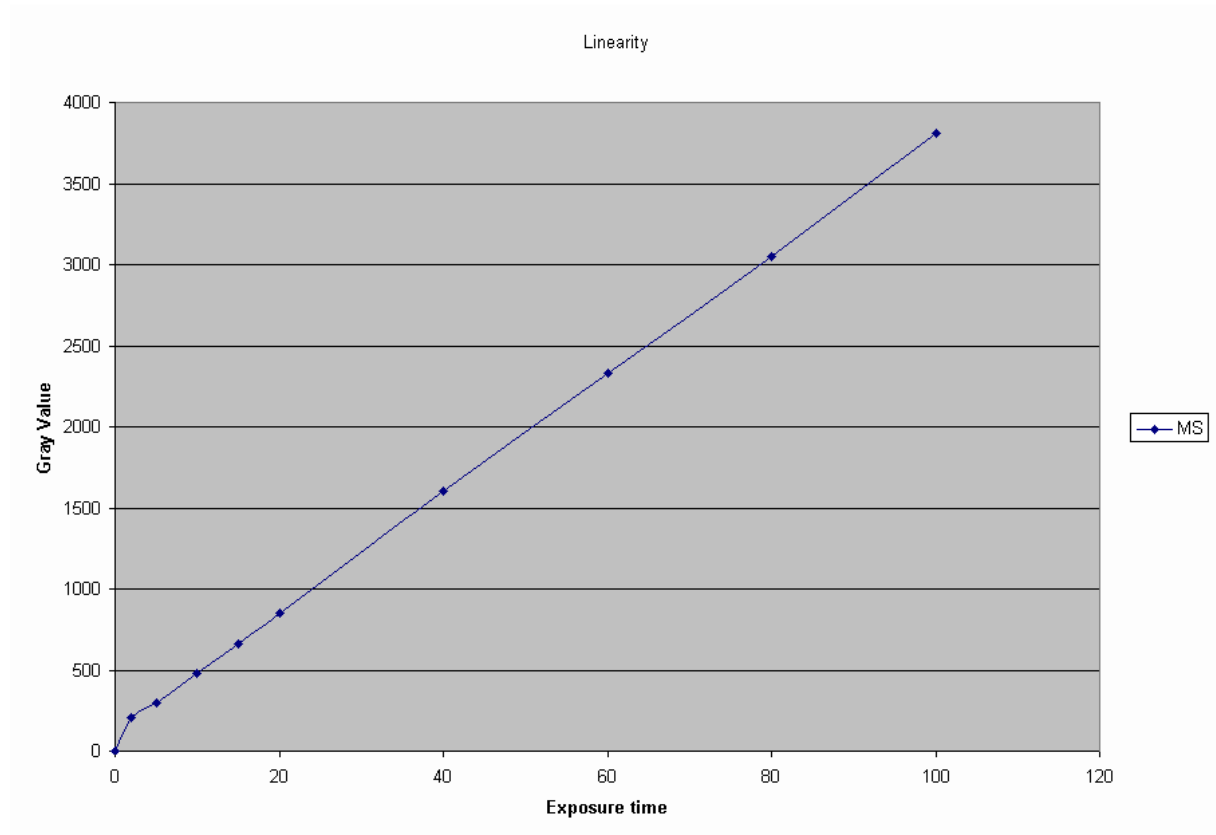


### Remark:

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".



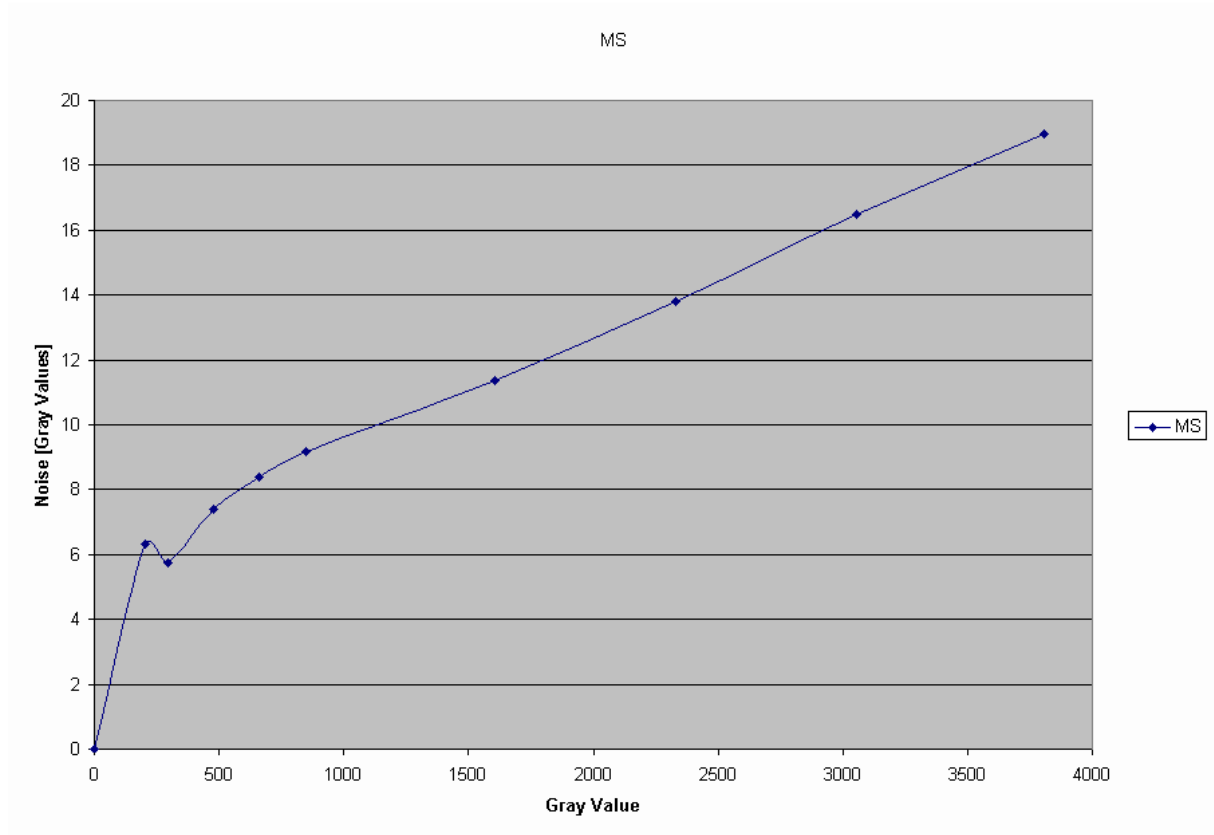
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

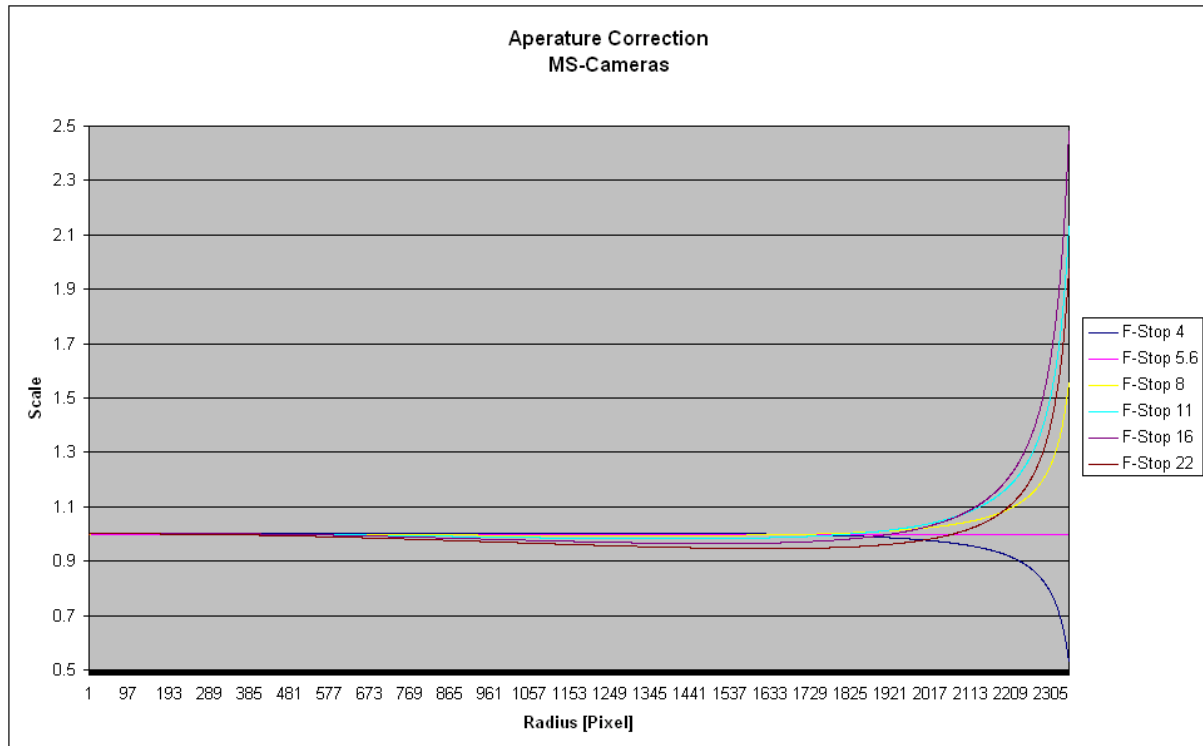
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

### Aperture Correction



**Remark:**

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

### Defect Pixel List

Number of defect pixels: 0  
 Number of defect clusters: 0  
 Number of defect columns: 1

Nr Row Column

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
0	1303	1501	2047	1501

**Remark**

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



## Calibration Certificate

N<sup>o</sup> 00114327

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Red  
Serial Number            00114327

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66


Date of Calibration                      15.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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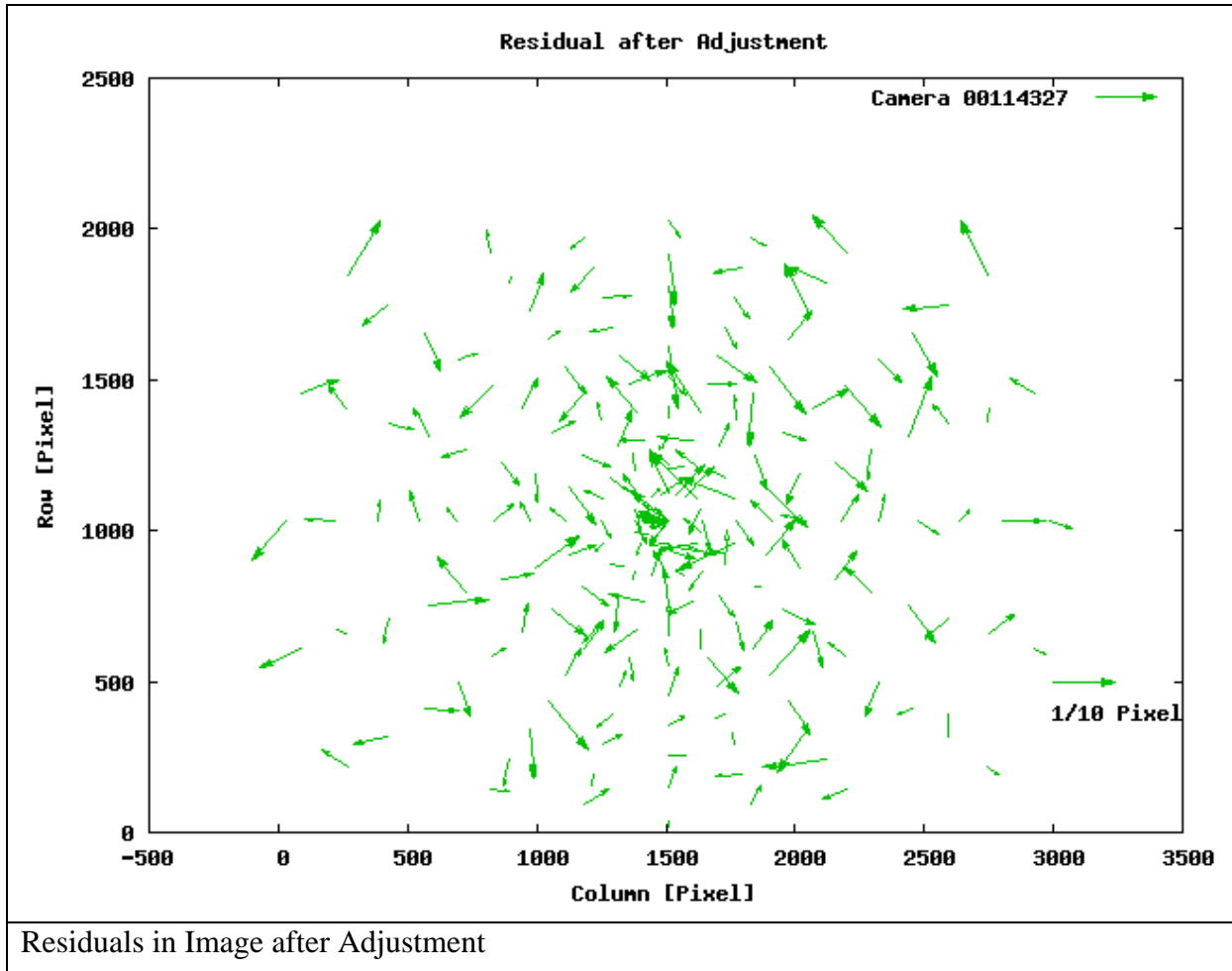
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00114327

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0003087	1.277E-06
	$y_0$	-0.0001204	9.013E-07
Focal Length [m]	$\Delta f$	-9.64E-05	4.726E-07
Radial Distortion	$K_1$	-141.8	0.3975
	$K_2$	223300	2537
	$K_3$	-148300000	4569000
Decentering distortion	$P_1$	0.001594	0.0006639
	$P_2$	-0.001363	0.0004121
In Plane Distortion	$B_1$	0.0001553	1.169E-05
	$B_2$	-3.541E-05	9.449E-06

Adjusted Focal length = 0.025+ dc =0.0249036 [m]



Max Residual [ $\mu\text{m}$ ]: 1.2

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

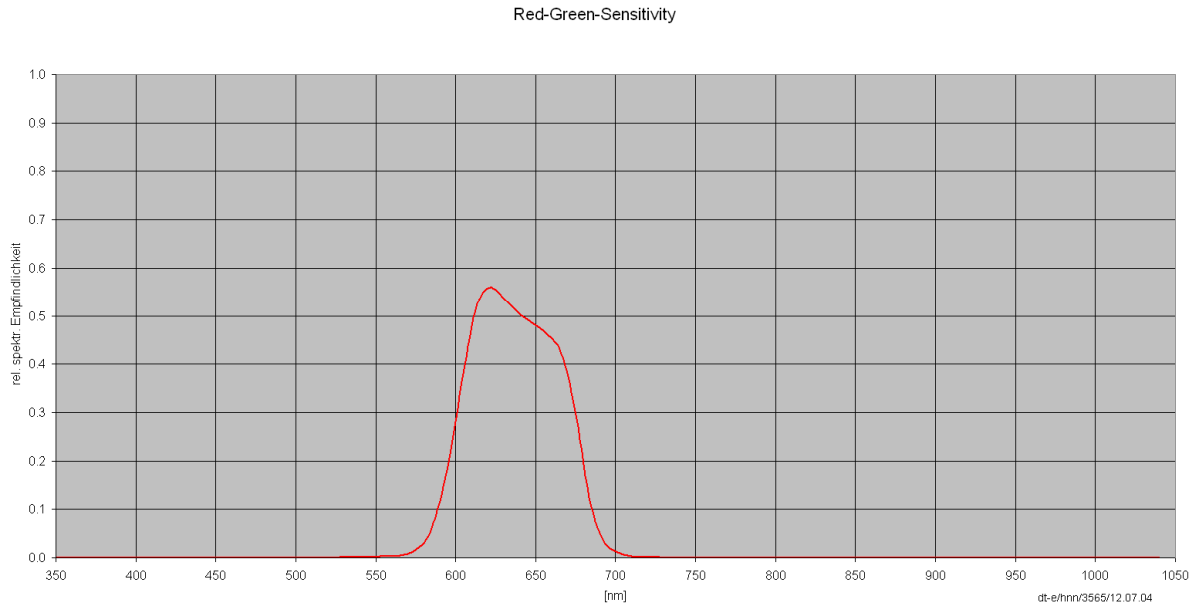
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00114327
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

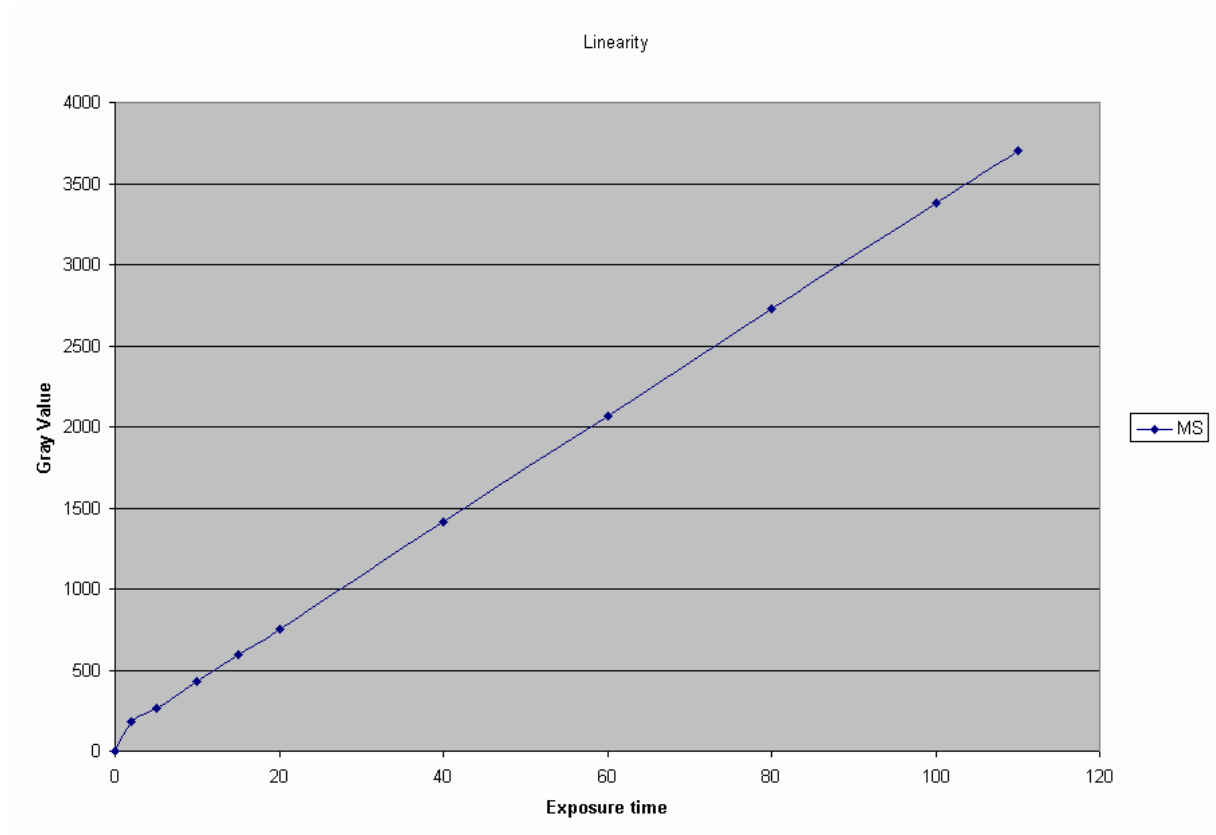
## Sensitivity of camera



**Remark:**

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

### Sensor Linearity

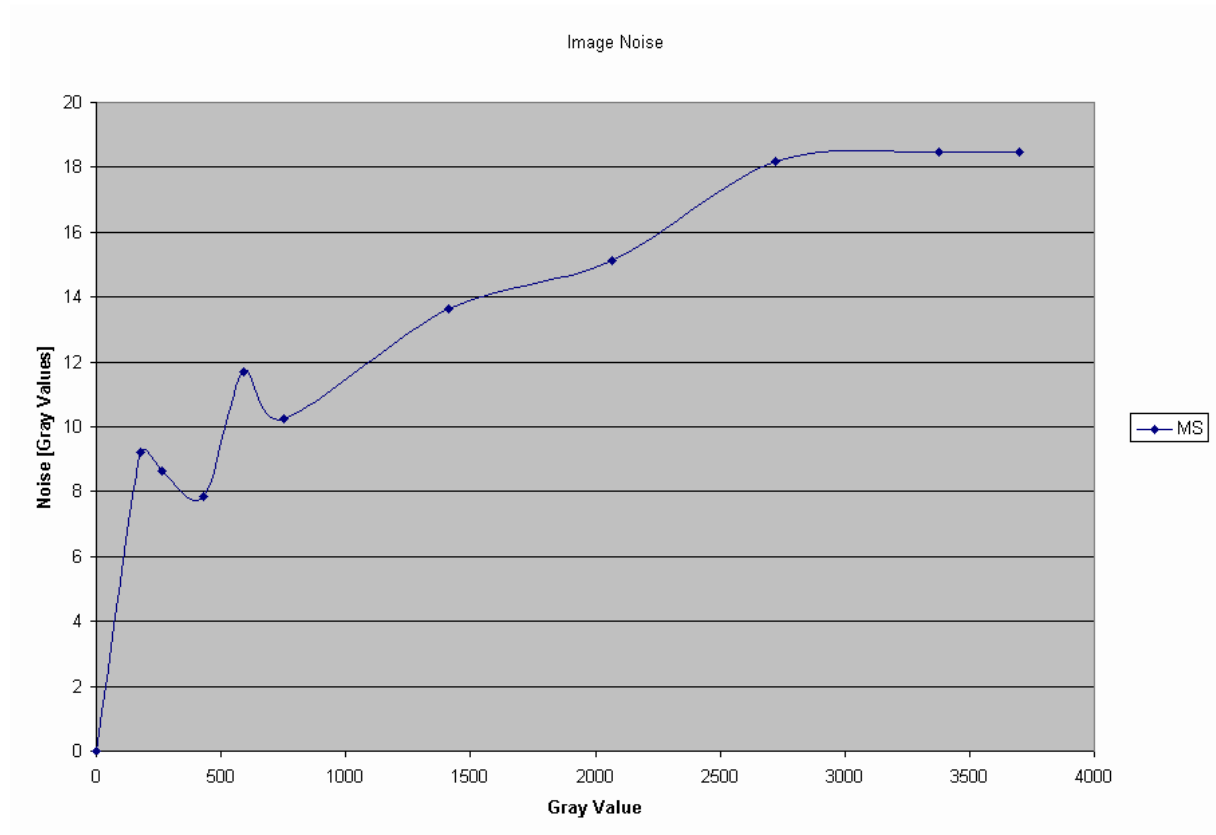


**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".



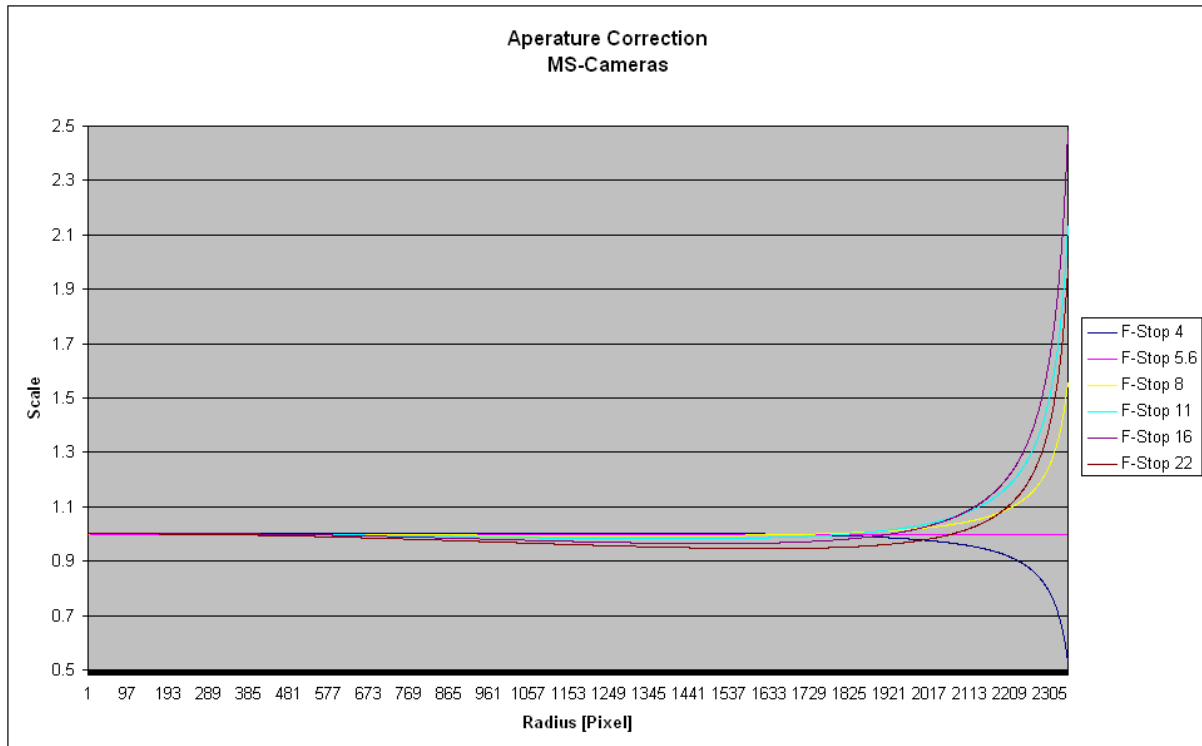
### Sensor Noise



**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

### Aperture Correction



Remark:

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

### Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.



Calibration Protocol  
DMC01 - 0050



**Calibration Certificate**

**N<sup>o</sup> 00114330**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-Green  
Serial Number              00114330

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    66

Date of Calibration                      16.Okt.2008

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CertifiedDate

30.Apr.2010

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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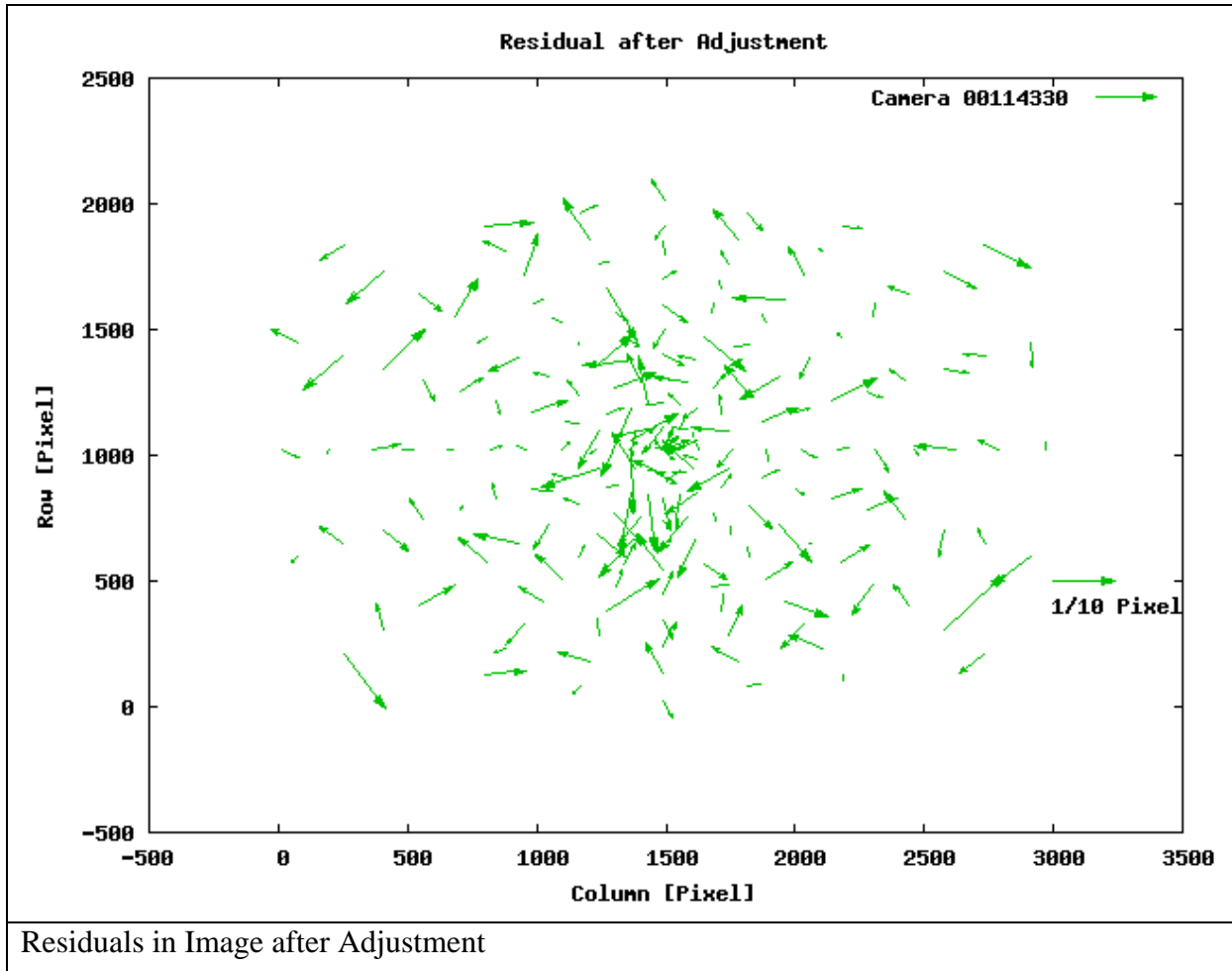
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00114330

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0005083	1.255E-06
	$y_0$	3.45E-05	8.858E-07
Focal Length [m]	$\Delta f$	-8.009E-05	4.643E-07
Radial Distortion	$K_1$	-142.2	0.3905
	$K_2$	229000	2491
	$K_3$	-158700000	4486000
Decentering distortion	$P_1$	0.0008608	0.0006523
	$P_2$	-0.0009306	0.0004049
In Plane Distortion	$B_1$	-1.07E-05	1.149E-05
	$B_2$	-1.644E-05	9.285E-06

Adjusted Focal length = 0.025+ dc =0.02491991 [m]



Max Residual [ $\mu\text{m}$ ]: 1.6

Threshold [ $\mu\text{m}$ ]: 8.5

Remarks:

The images after the post processing are distortion free. For interior orientation parameters of the DMC virtual image see section: "Calibration Parameter of the virtual images".

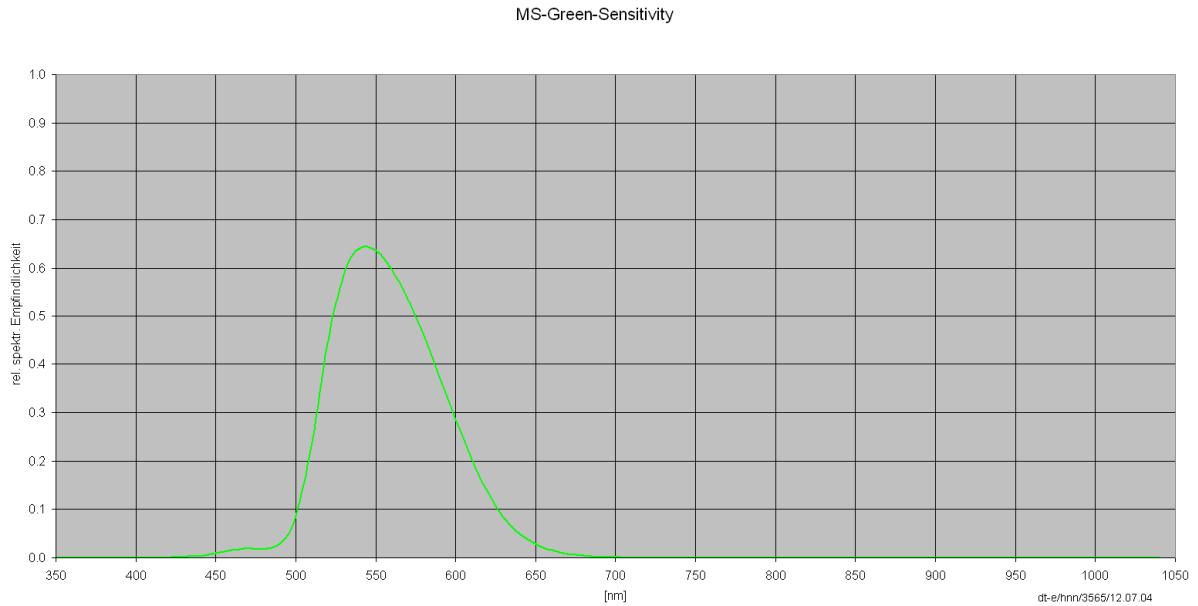
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

In this section you'll find the radiometric calibration results.

Camera ID	00114330
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

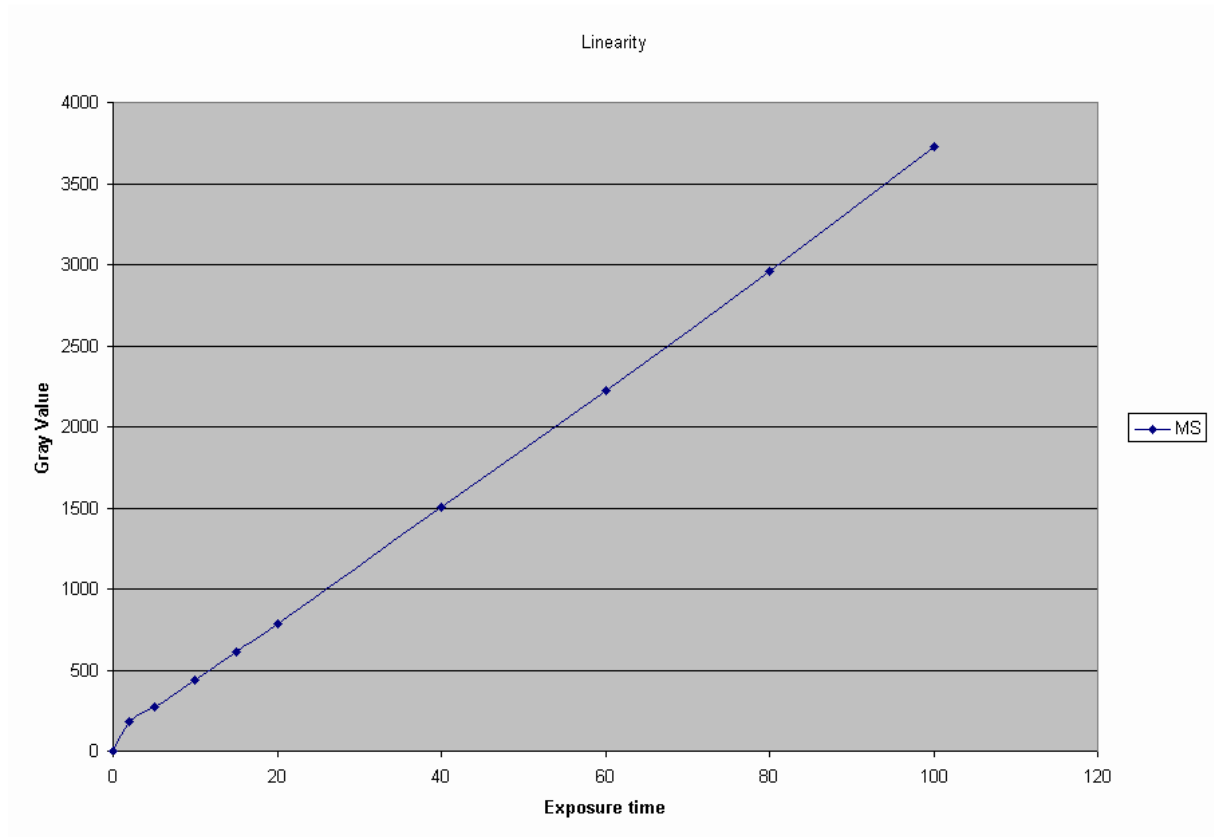
## Sensitivity of camera



### Remark:

Measurement is done without the influence of the shutter and the Analog/Digital converter. This graph is similar for the same lens and filter revision numbers. For more details see Appendix: "Radiometric Calibration Model".

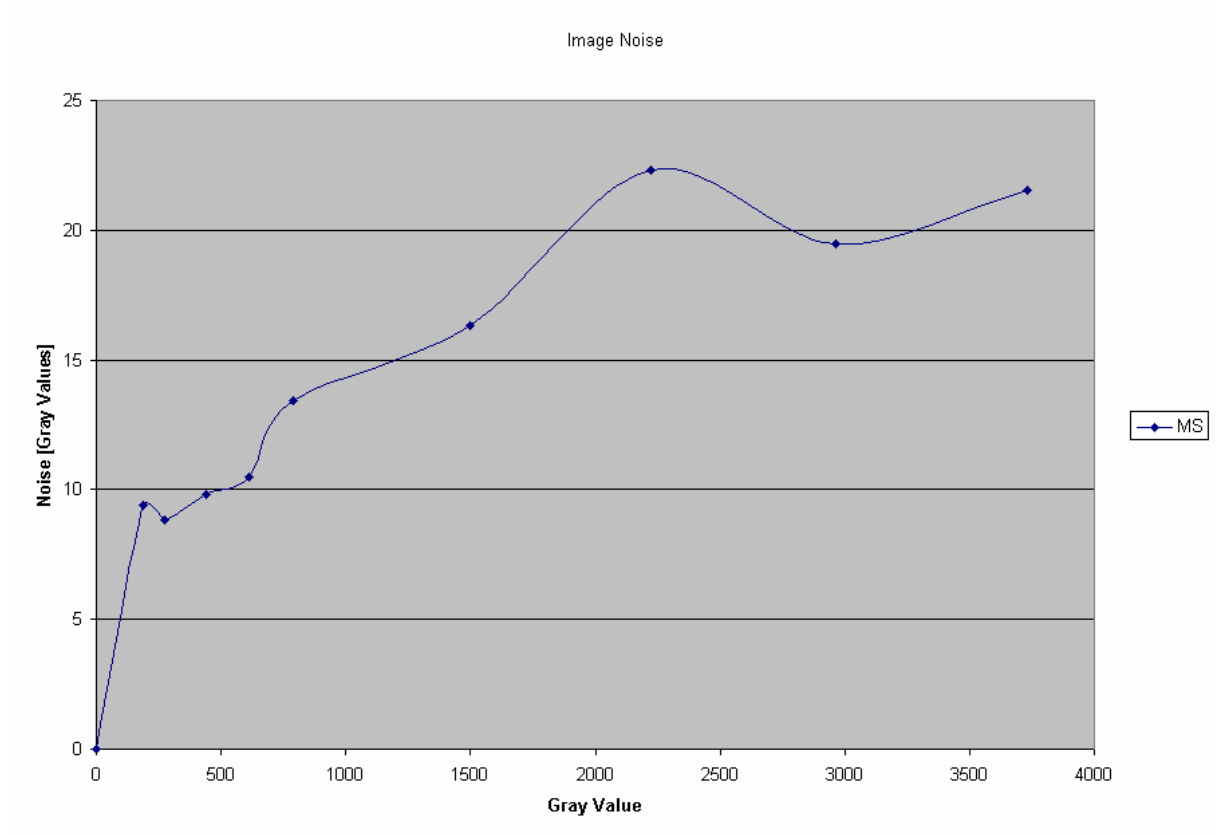
### Sensor Linearity



**Remark:**

The sensor linearity is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".

### Sensor Noise

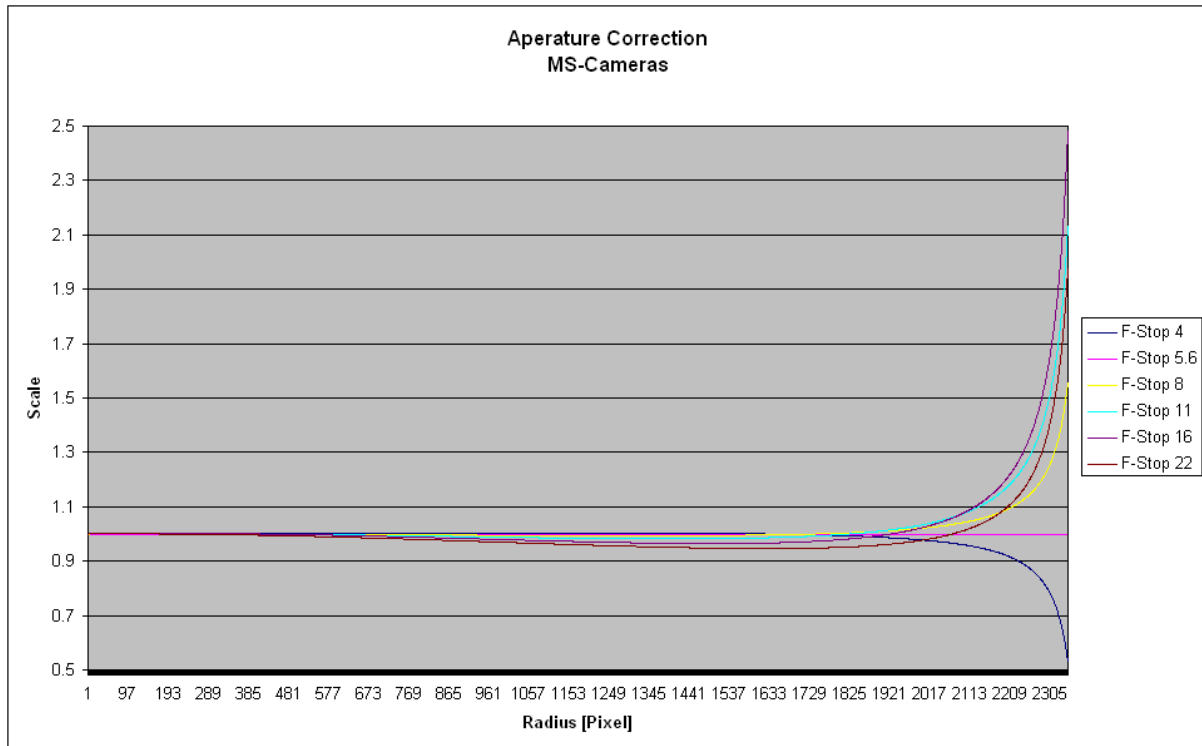


**Remark:**

The sensor noise is measured for each camera. For more details see Appendix: "Radiometric Calibration Model".



### Aperture Correction



Remark:

This measurement is similar for the same aperture revision number. For more details see Appendix: "Radiometric Calibration Model".

### Defect Pixel List

Number of defect pixels: 0

Number of defect clusters: 0

Number of defect columns: 0

Nr Row Column

Defect Column RowStart ColumnStart RowEnd ColumnEnd

Remark

See Appendix for definition of defect pixels and maximal allowed numbers.

## Defect Pixel Recognition

	Description	CCD Spec	Radiometric Calibration
Pixel	Bright image	Pixel whose signal, at nominal light (illumination at 50% of the linear range), deviates more than $\pm 30\%$ from its neighboring pixels.	Using a lower threshold for image quality
	Dark image	Pixel whose signal, in dark, deviates more than 6mV from its neighboring pixels (about 1% of nominal light).	
	Max Count	PAN < 1000 MS < 36	

	Description	CCD Spec	Radiometric Calibration
Column	Definition	A column which has more than 12 pixel defects. Column defects must be horizontally separated by 3 columns.	Using a lower threshold for image quality
	Recognition (bright and dark)	Same as defect pixel recognition	
	Max Single column	PAN $\leq 50$ MS $\leq 1$	
	Max double Column	PAN $\leq 4$ MS $\leq 0$	

## Bibliography

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Fraser C., Digital Camera self calibration. ISPRS Journal of Photogrammetry and Remote Sensing, (1997, 5284): 149-159

Zeitler W., Dörstel C., Jacobsen K. (2002): Geometric calibration of the DMC: Method and Results, Proceedings ASPRS, Denver, USA.