



Calibration Protocol  
DMC01-107



# Calibration Certificate

Digital Mapping Camera (DMC)

DMC Serial Number: **DMC01-107**

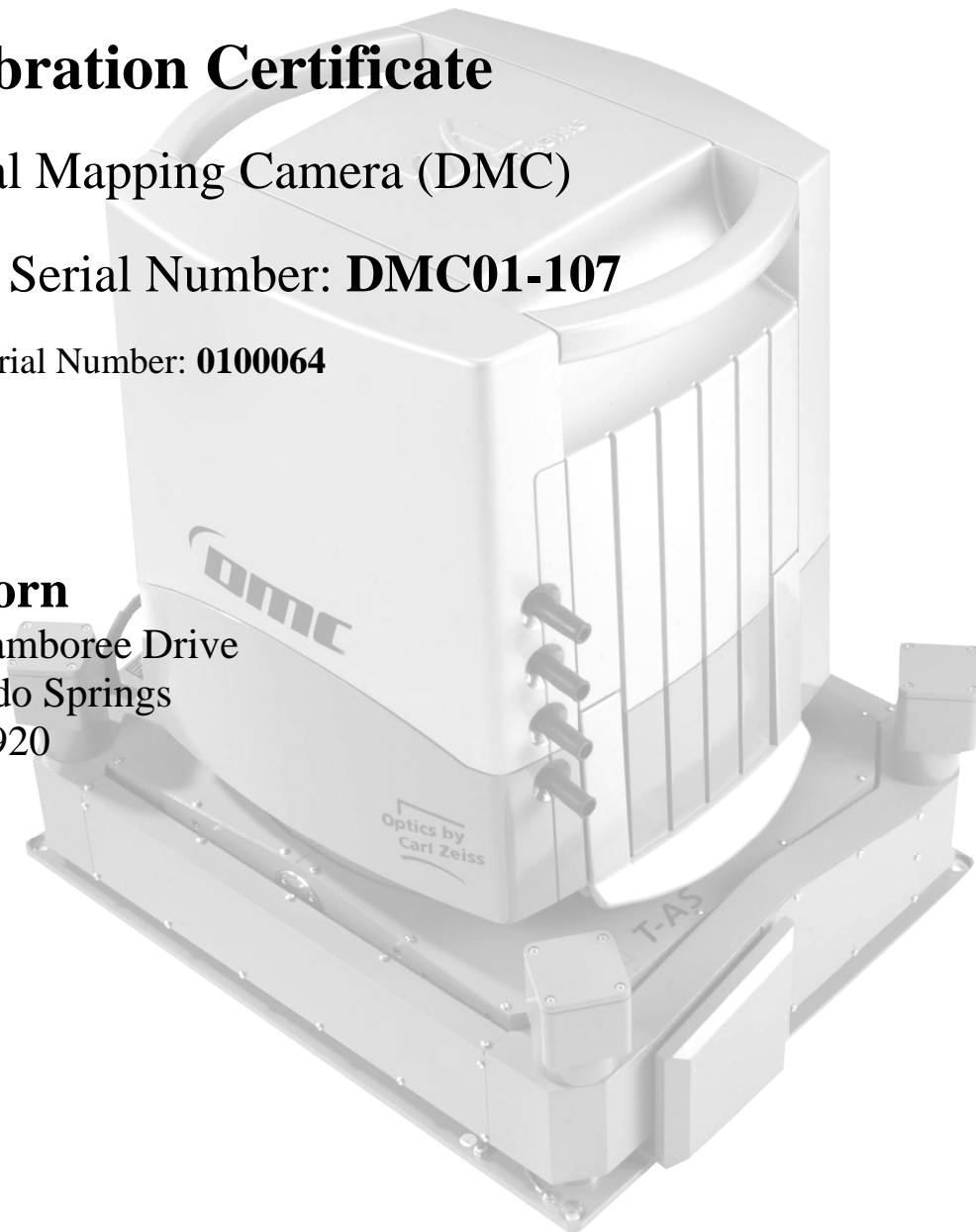
CBU Serial Number: **0100064**

For

**Sanborn**

1935 Jamboree Drive  
Colorado Springs  
CO 80920

USA



## System Overview

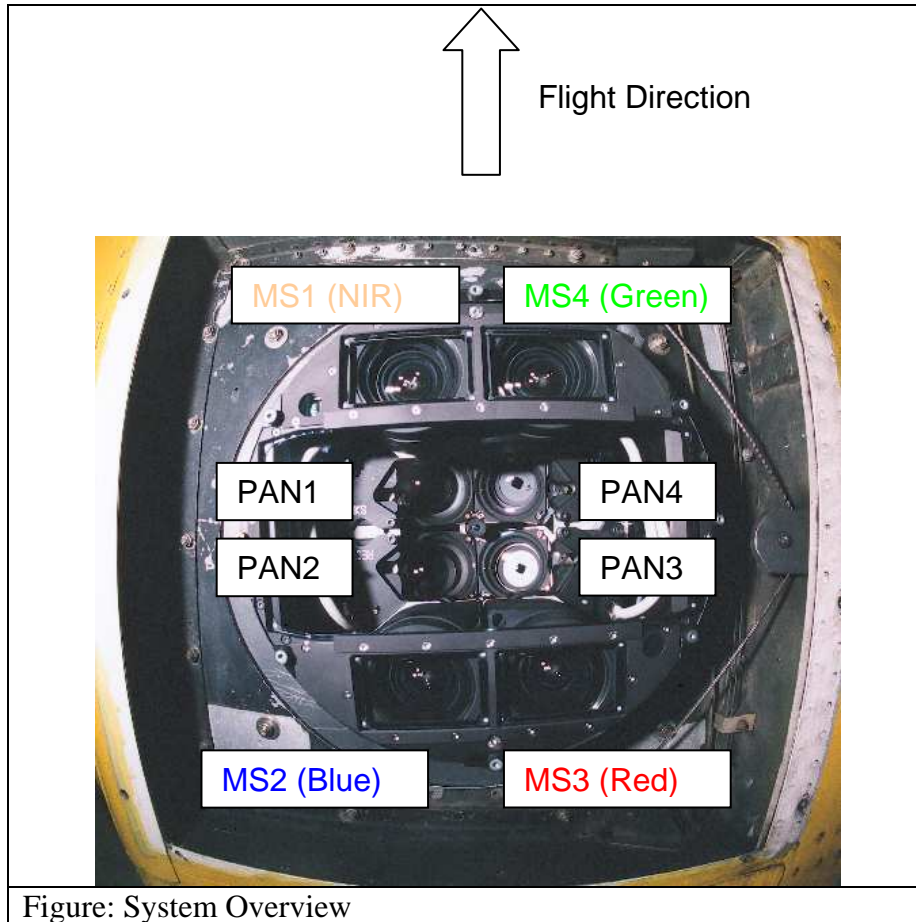
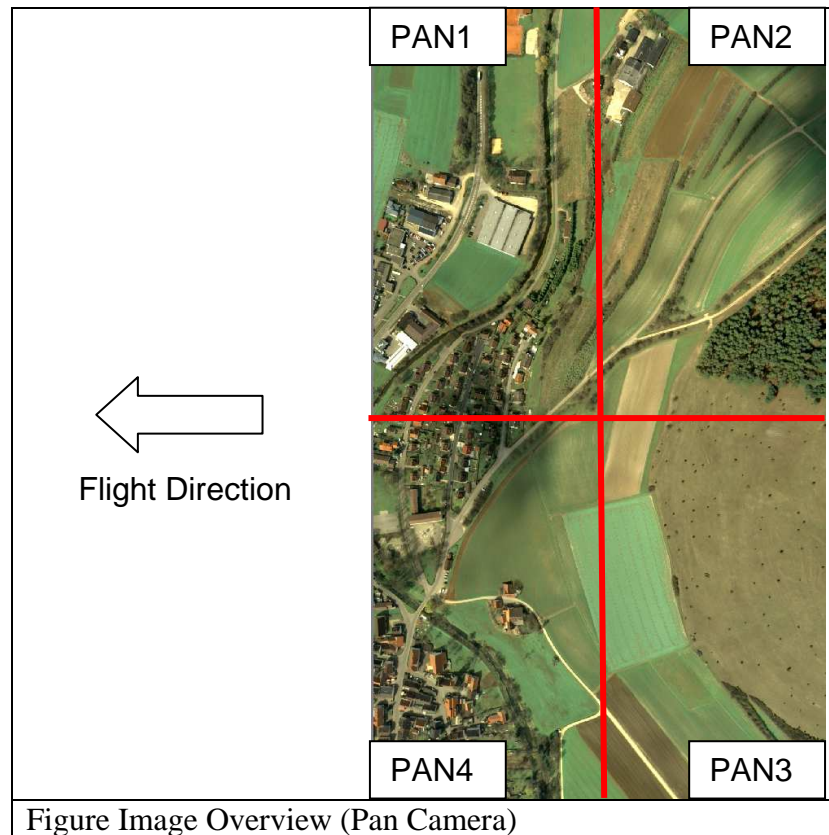


Figure: System Overview



**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  
DMC01-107



**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  
DMC01-107



### Camera Serial Number and Burn-In flights

	Burn In Flight: 01.11.2007					
Camera	Serial Number	Calib. Date				
PAN1	00115757	18.10.2007				
PAN2	00115740	09.10.2007				
PAN3	00115766	11.10.2007				
PAN4	00115769	10.10.2007				
MS1 (NIR)	00115846	01.10.2007				
MS2 (Blue)	00115856	02.10.2007				
MS3 (Red)	00115849	01.10.2007				
MS4 (Green)	00115844	11.10.2007				

## Camera Orientation PAN-Cameras (Burn-In Flight 01.11.2007)

Camera (Serial Number)	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Omega [Deg] (Accuracy)	Phi [Deg] (Accuracy)	Kappa [Deg] (Accuracy)
PAN1 (00115757)	0.064 (0)	-0.079 (0)	1000 (0)	18.018 (0.001)	10.024 (0.001)	86.689 (0.001)
PAN2 (00115740)	-0.064 (0)	-0.079 (0)	1000 (0)	17.919 (0.001)	-10.254 (0.001)	93.337 (0.001)
PAN3 (00115766)	-0.064 (0)	0.079 (0)	1000 (0)	-18.021 (0.001)	-10.002 (0.001)	-92.875 (0.001)
PAN4 (00115769)	0.064 (0)	0.079 (0)	1000 (0)	-17.914 (0.001)	10.234 (0.001)	-86.710 (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 5.2, from Intergraph Z/I Imaging photogrammetric product suite.

Platform calibration performed by

  
Dipl. Ing. C. Müller

05.11.2007  
Date

## Additional System Components (Burn-In Flight 30.10.2007)

Leverarms:

Component	X [m] (Accuracy)	Y [m] (Accuracy)	Z [m] (Accuracy)	Axis "1" X points	Axis "2" Y points	Axis "3" Z points
IMU	(0)	(0)	(0)			

Boresight Angles:

Component	Roll [Deg] (RMS)	Pitch [Deg] (RMS)	Yaw [Deg] (RMS)
IMU			

The results of the orientation of the IMU were generated with support of ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Calibration performed by

\_\_\_\_\_  
Dipl. Ing. C. Müller

\_\_\_\_\_  
Date

## Aerotriangulation Results (Burn-In Flight 01.11.2007)

	Photo Scale	1:5000
	Flying Height [m]	600 AGL
	Flying Altitude [m]	1200 AMSL
	Run-Spacing [m]	539.1
	Base-Length [m]	161.3
	Number of Exposures	155
	Side-lap [%]	35
	End-lap [%]	65
	Terrain Height [m]	600
	Number of strips	7
	Photos in one strip	23 vertical 17 horizontal
	Photos Used	149
	Control Points Used	39
Check Points Used		
GSD [cm]	6	

### Statistic results:

<b>Matching results: 0 Weak Areas - covered with clouds</b>	
<b>Whole Block</b>	149 exposures used 0 exposures not used
<b>Whole Block</b>	<b>Sigma relativ: 1.639 um</b>
<b>Whole Block</b>	<b>Sigma absolut: 1.661 um</b>
<b>Whole Block</b>	
Photo-T Parameters and Results for Project EL5000_n	
PhotoT Triangulation Options	
Adjustment Mode	: Absolute
Precision Computation	: Enabled
Error Detection	: Enabled
Camera Calibration	: Disabled
Self-Calibration	: Disabled
Given EO/GPS	: Disabled
Antenna Offsets	: Disabled
GPS Shift/Drift Correction	: Disabled
INS Shift/Drift Correction	: Disabled



Parameters					
	Parameter	X/Omega	Y/Phi	Z/Kappa	XY
	RMS Control	0.062	0.084	0.096	0.074
	RMS Check				
	RMS Limits	0.100	0.100	0.150	
	Max Ground Residual	0.172	0.194	0.259	
	Residual Limits	0.100	0.100	0.150	
	Mean Std Dev Object	0.011	0.011	0.023	
	RMS Photo Position				
	RMS Photo Attitude				
	Mean Std Dev Photo Position	0.017	0.020	0.015	
	Mean Std Dev Photo Attitude	0.001	0.002	0.001	
Key Statistics					
	Sigma:	1.7 $\mu$ m			
	Number of iterations:	9			
	Degrees of Freedom:	32671			

The results of the Aerotriangulation were generated with ImageStation Automatic Triangulation (ISAT), Version 5.1, from Intergraph Z/I Imaging photogrammetric product suite.

Aerotriangulation performed by

  
 Dipl. Ing. C. Müller

05.11.2007  
 Date



Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115757**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115757

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70


Date of Calibration                      18.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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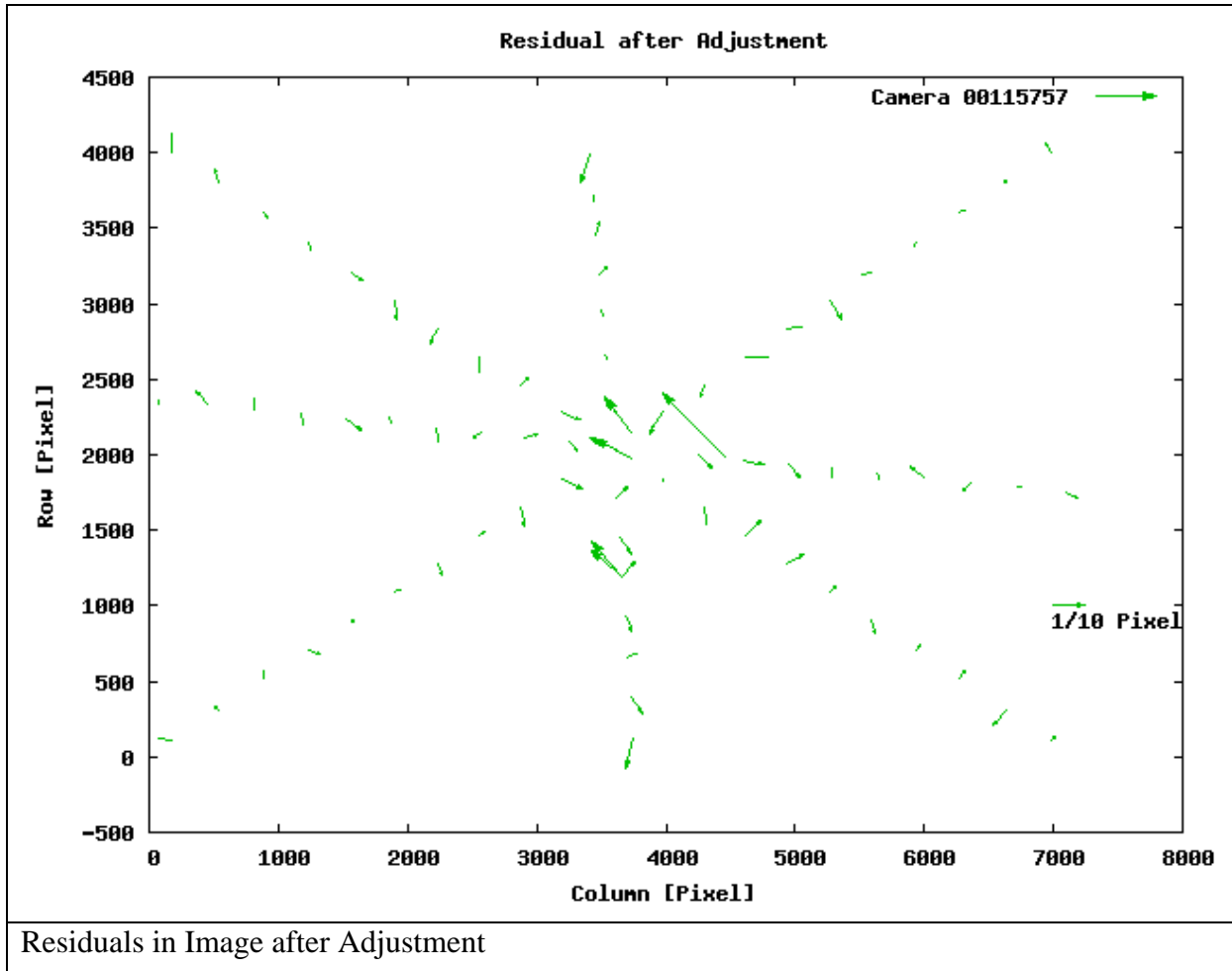
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115757

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	1.188E-05	1.015E-05
	$y_0$	-0.0001223	6.159E-06
Focal Length [m]	$\Delta f$	-0.0004126	1.79E-06
Radial Distortion	$K_1$	0.637	0.04666
	$K_2$	-234.8	42.36
	$K_3$	-40640	11210
Decentering distortion	$P_1$	-2.728E-05	0.0002312
	$P_2$	0.0004153	0.0001173
In Plane Distortion	$B_1$	6.892E-06	1.23E-05
	$B_2$	3.595E-05	7.188E-06

Adjusted Focal length = 0.12+ dc =0.1195874 [m]



Max Residual [ $\mu\text{m}$ ]: 3.2

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”.

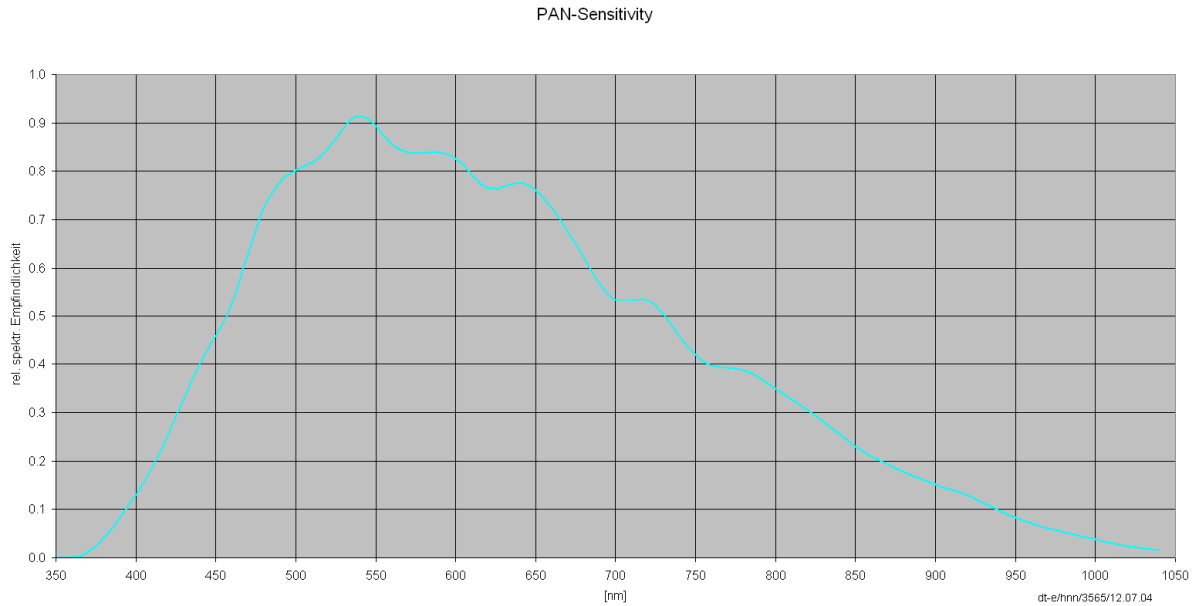
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115757
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

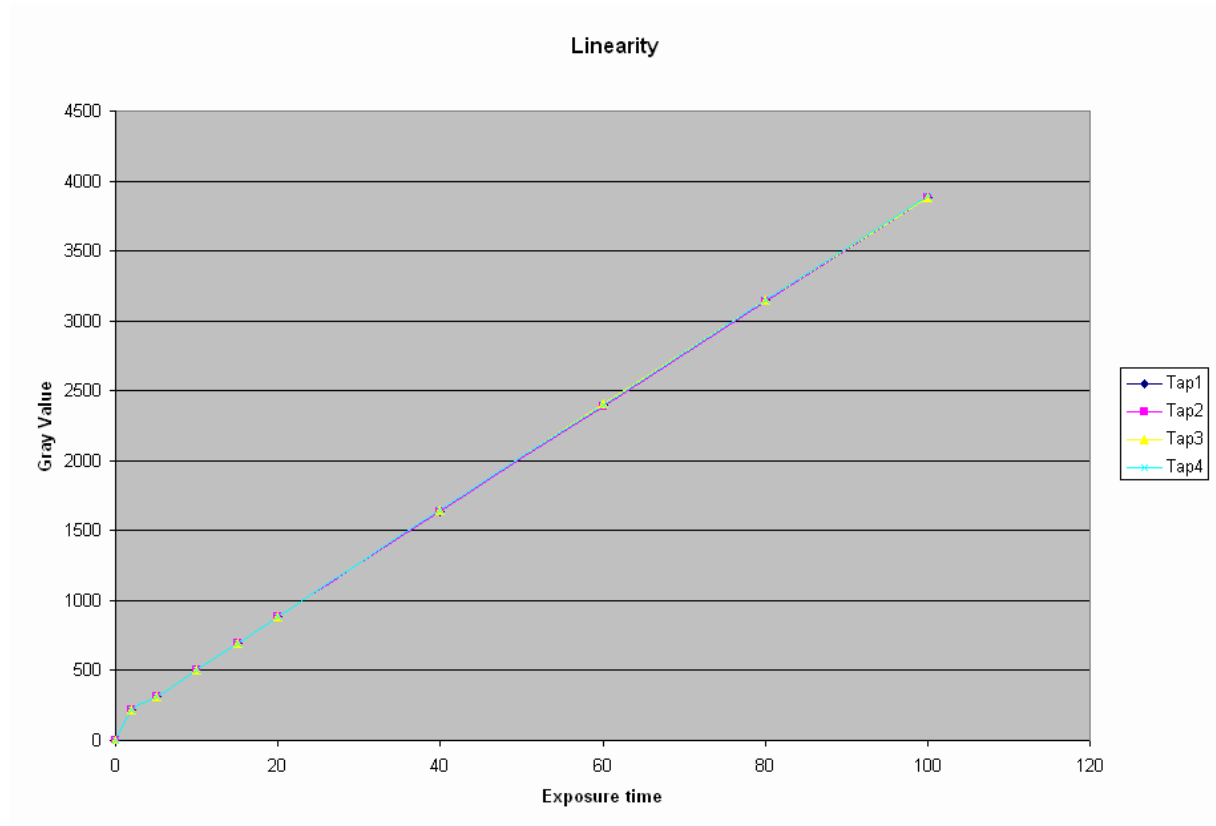
## Sensitivity of camera



**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".

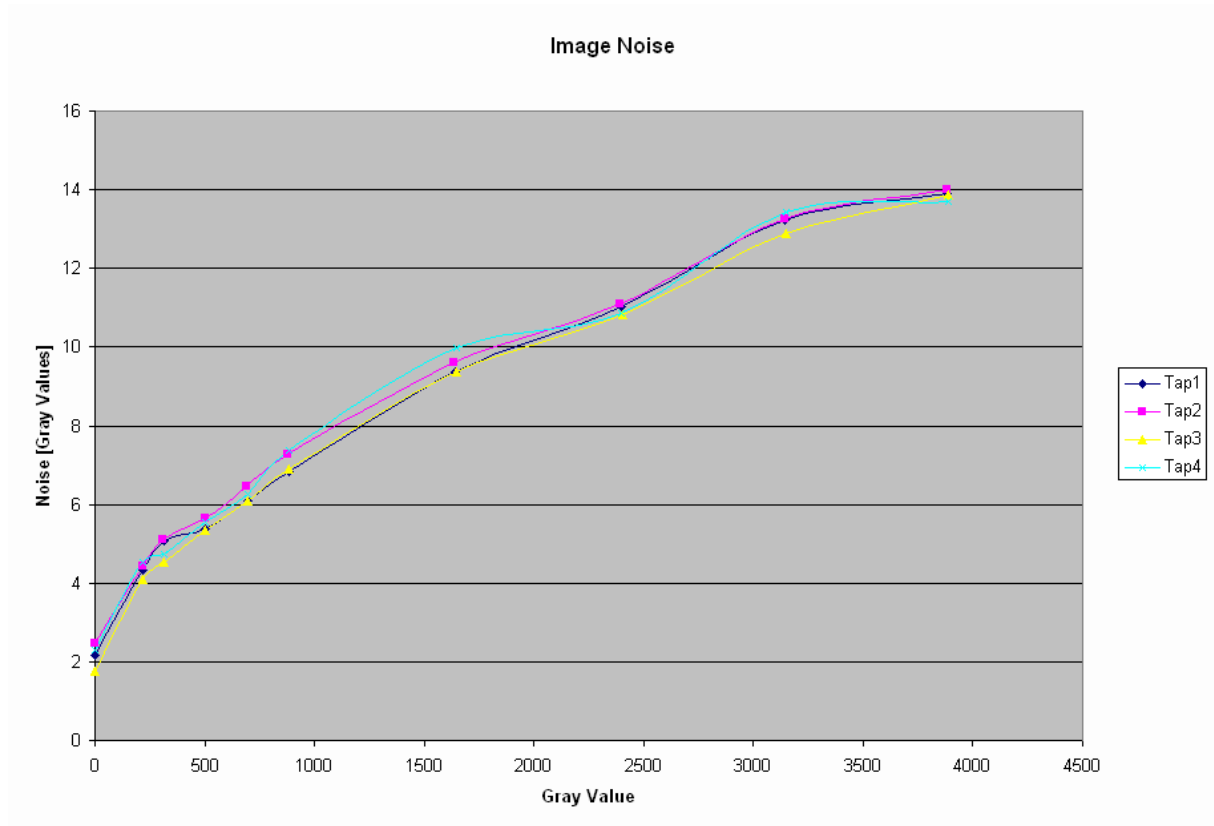
### Sensor Linearity



**Remark:**

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

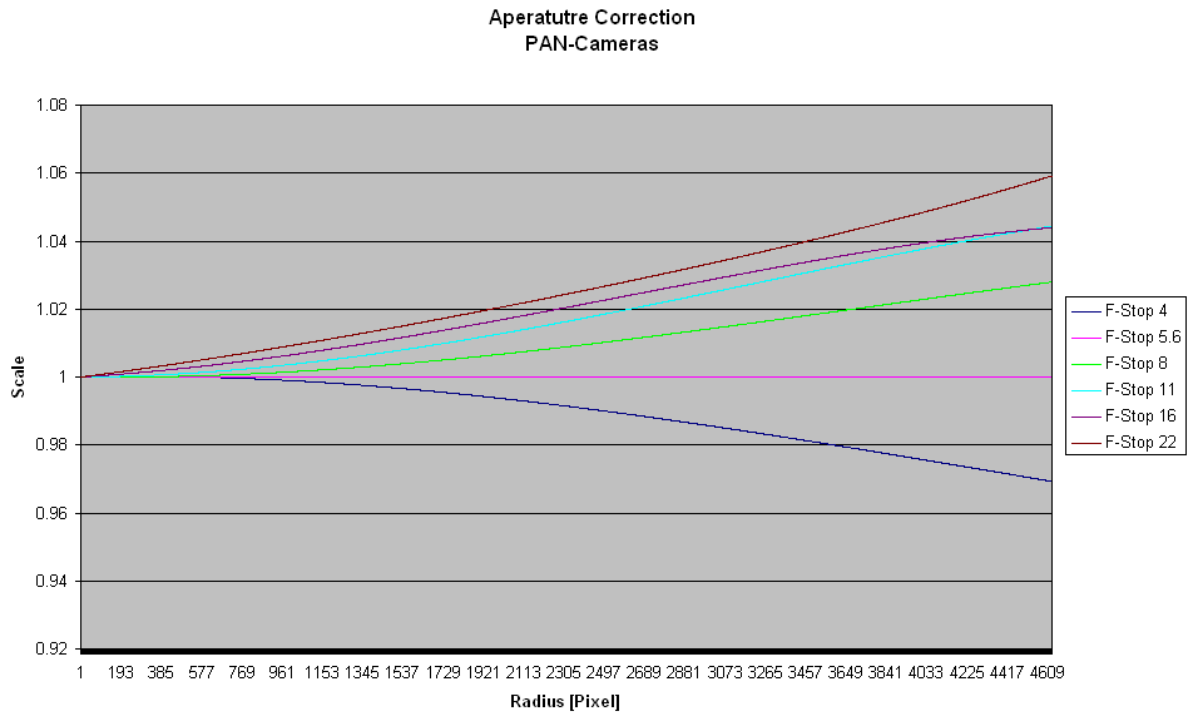
### Sensor Noise



**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: 3  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr	Row	Column
0	3607	2115
1	3608	2115
2	3826	4381

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01-107



## Remark

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



Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115740**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115740

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70


Date of Calibration                      09.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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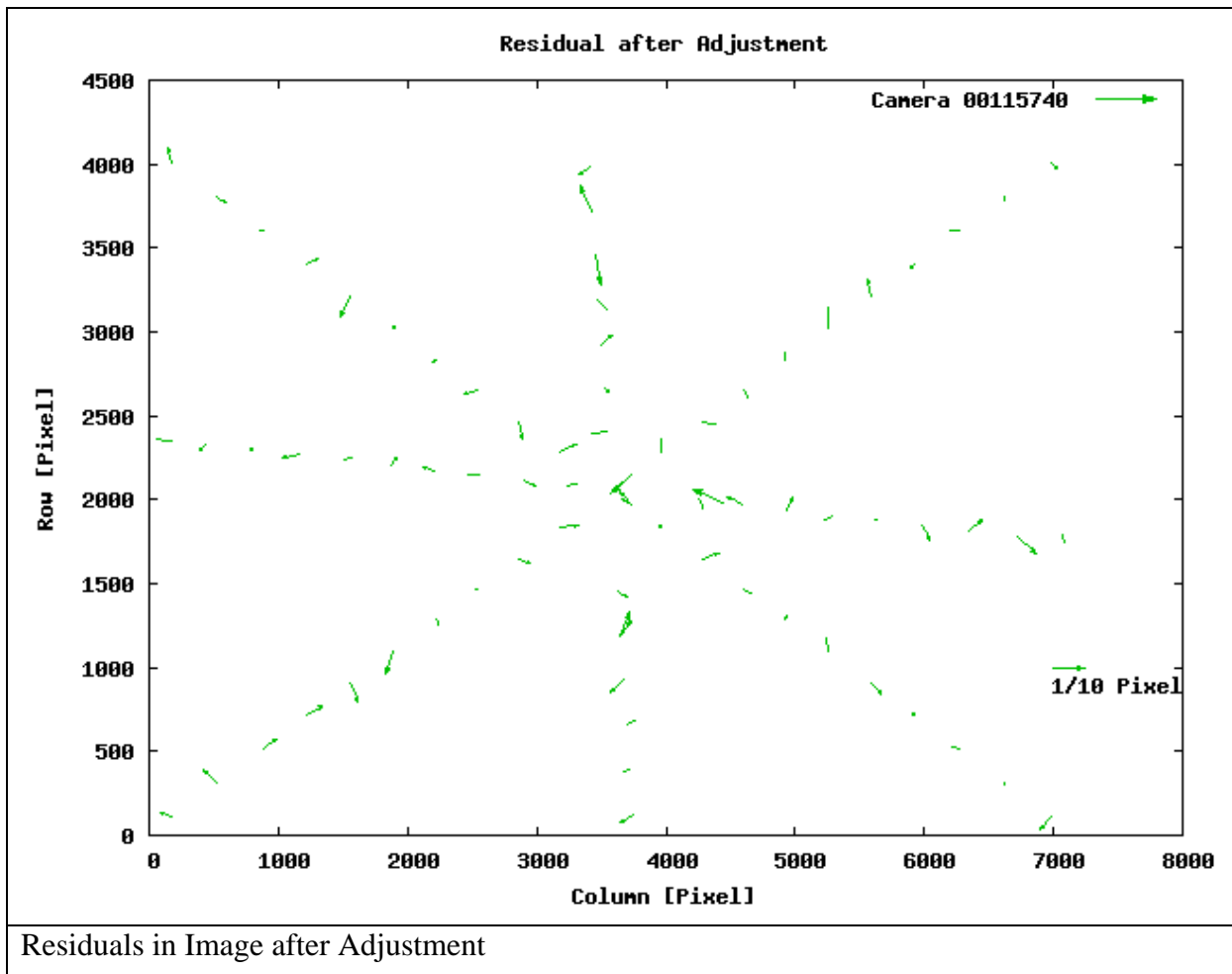
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115740

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-7.943E-05	6.824E-06
	$y_0$	-0.0001343	4.143E-06
Focal Length [m]	$\Delta f$	-0.0003865	1.197E-06
Radial Distortion	$K_1$	0.7017	0.0313
	$K_2$	-311.6	28.42
	$K_3$	-19960	7524
Decentering distortion	$P_1$	9.738E-05	0.0001555
	$P_2$	0.0004642	7.89E-05
In Plane Distortion	$B_1$	-1.593E-05	8.266E-06
	$B_2$	3.322E-05	4.836E-06

Adjusted Focal length = 0.12+ dc =0.1196135 [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".

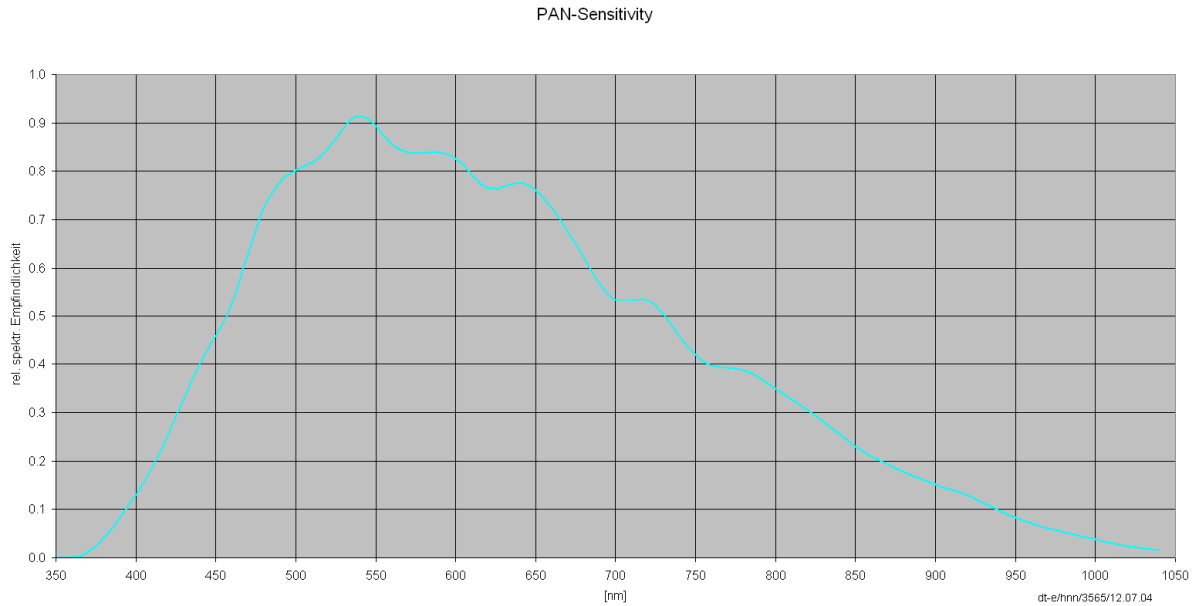
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115740
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

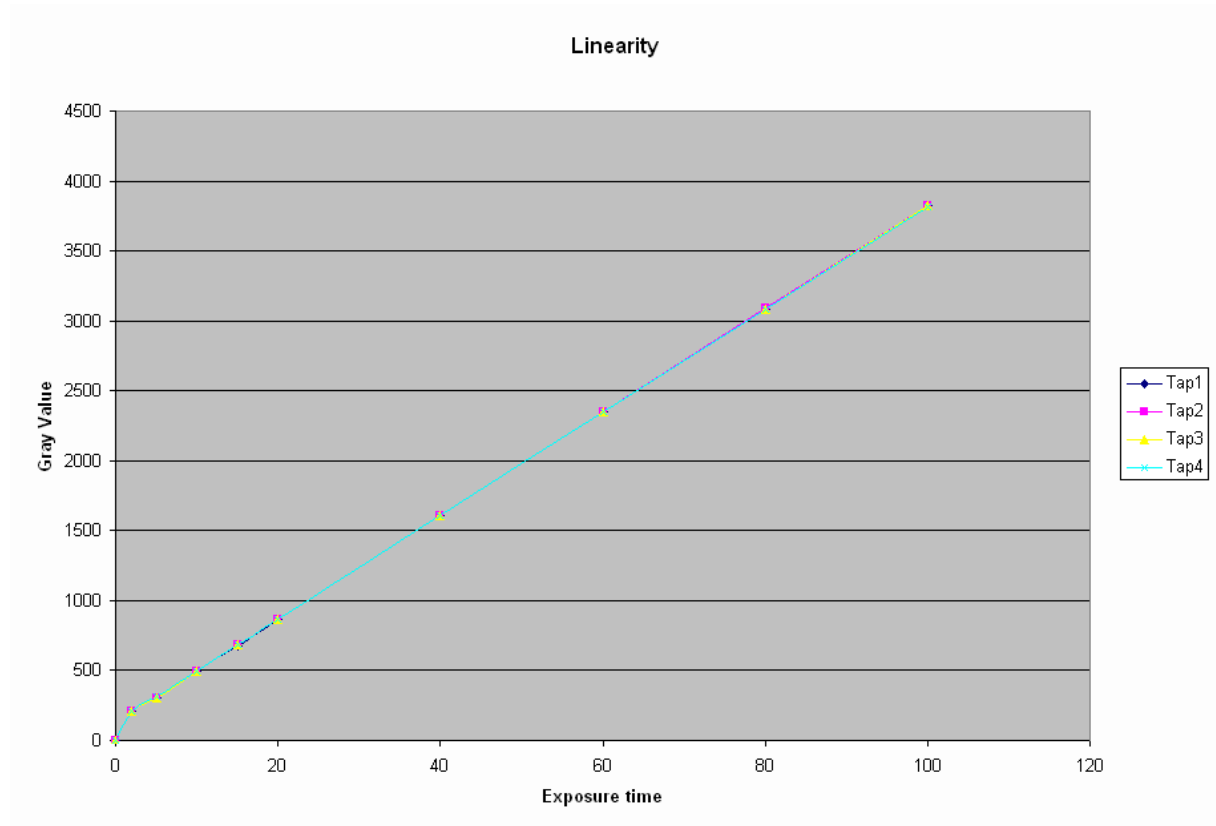
## Sensitivity of camera



**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".

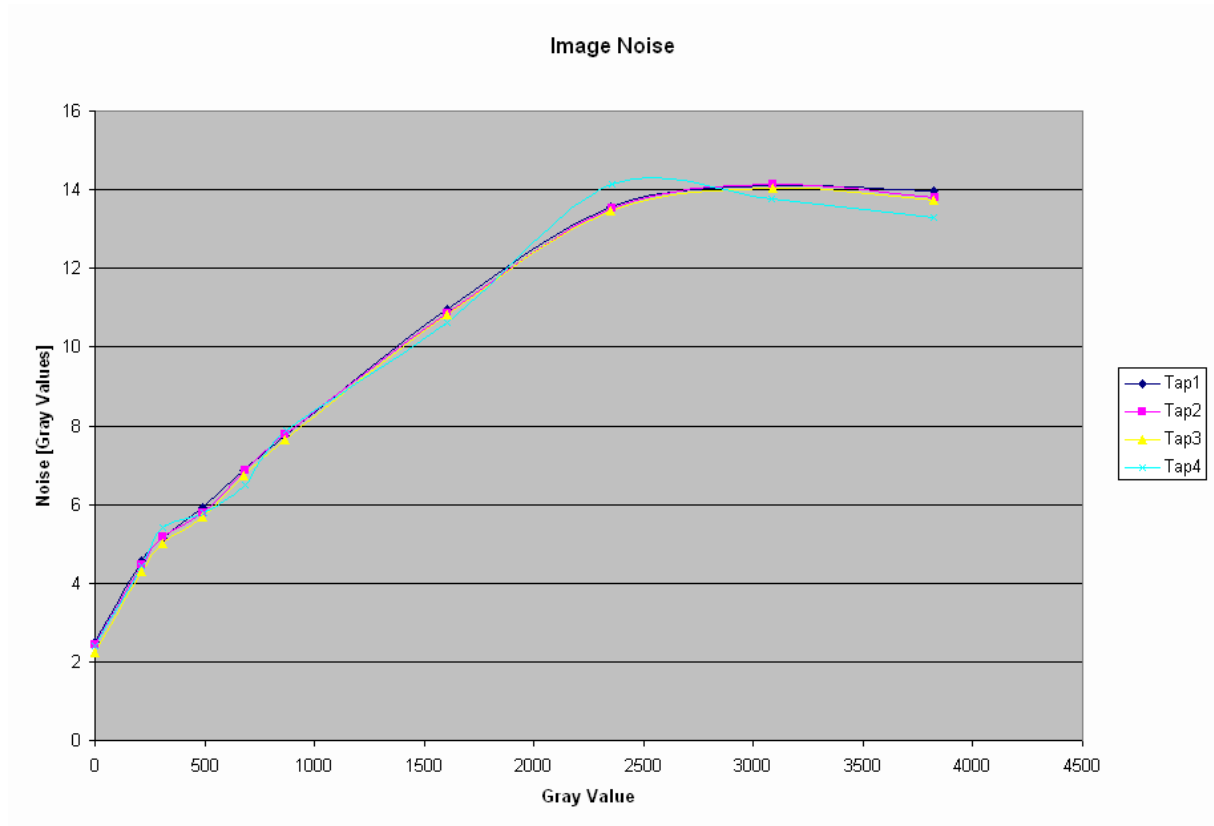
### Sensor Linearity



**Remark:**

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

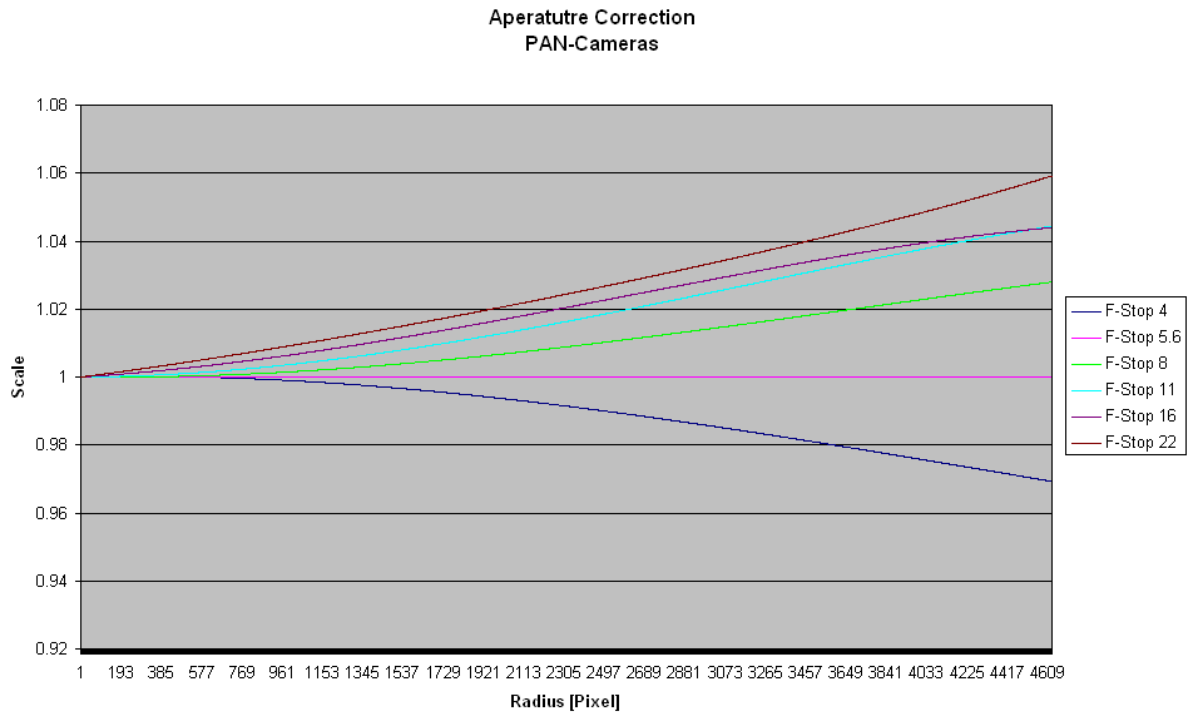
### Sensor Noise



**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: 3

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
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0	3691	444
---	------	-----

1	3690	445
---	------	-----

2	3691	445
---	------	-----

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01-107



## Remark

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



Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115766**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-Panchromatic  
Serial Number              00115766

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      11.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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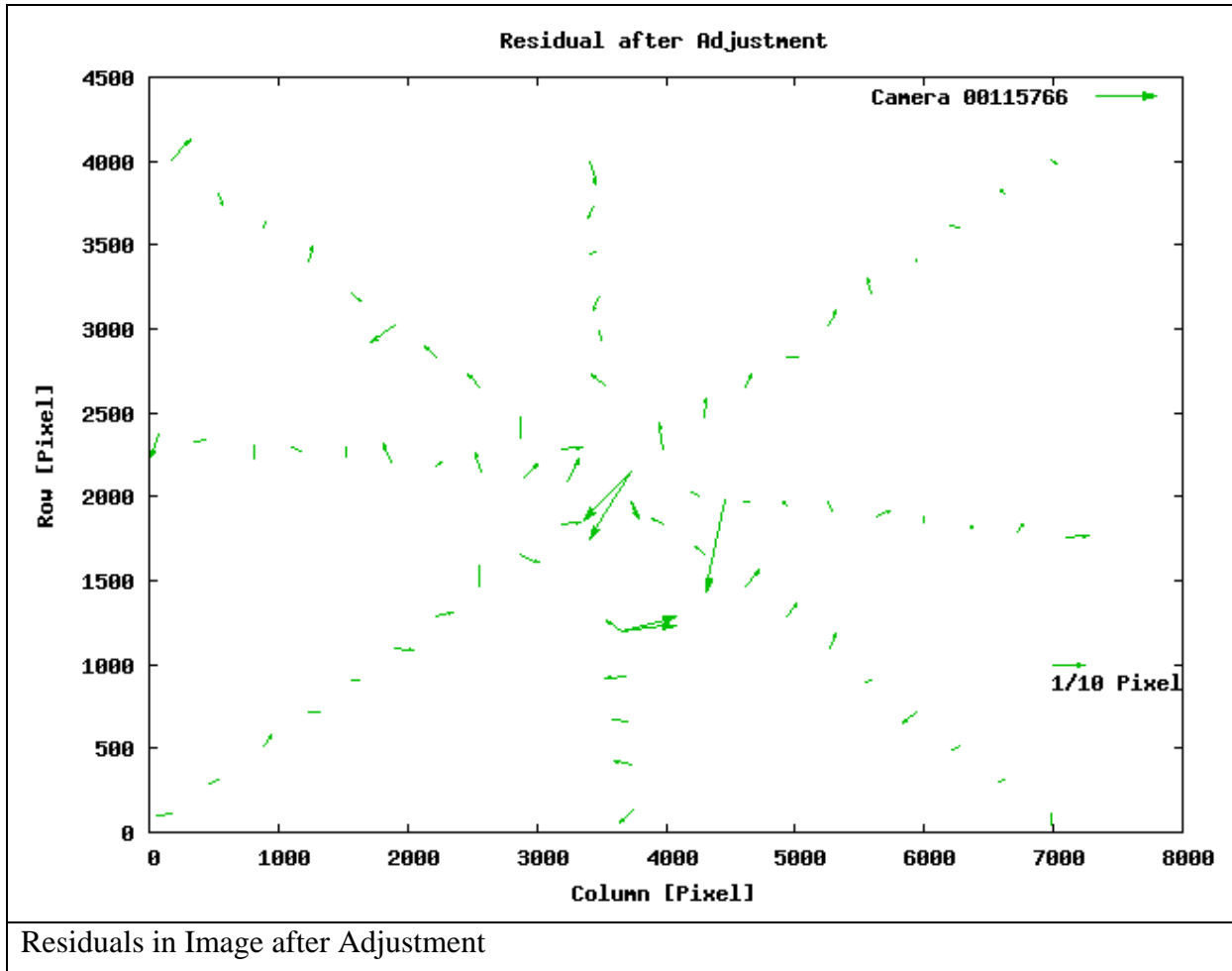
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115766

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-1.348E-05	1.082E-05
	$y_0$	-0.0002098	6.553E-06
Focal Length [m]	$\Delta f$	-0.0004424	1.907E-06
Radial Distortion	$K_1$	0.8209	0.04966
	$K_2$	-338.2	45.07
	$K_3$	-14020	11920
Decentering distortion	$P_1$	-0.0006886	0.0002466
	$P_2$	-0.0009171	0.0001246
In Plane Distortion	$B_1$	4.613E-05	1.307E-05
	$B_2$	1.634E-05	7.638E-06

Adjusted Focal length = 0.12+ dc =0.1195576 [m]



Max Residual [ $\mu\text{m}$ ]: 2.9

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”.

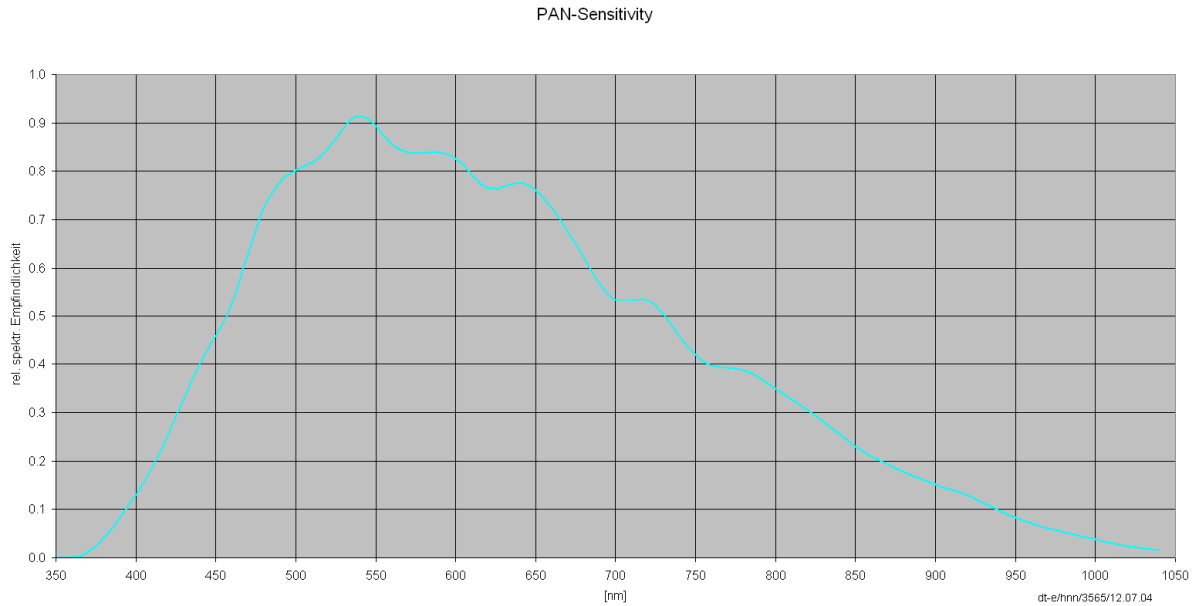
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115766
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

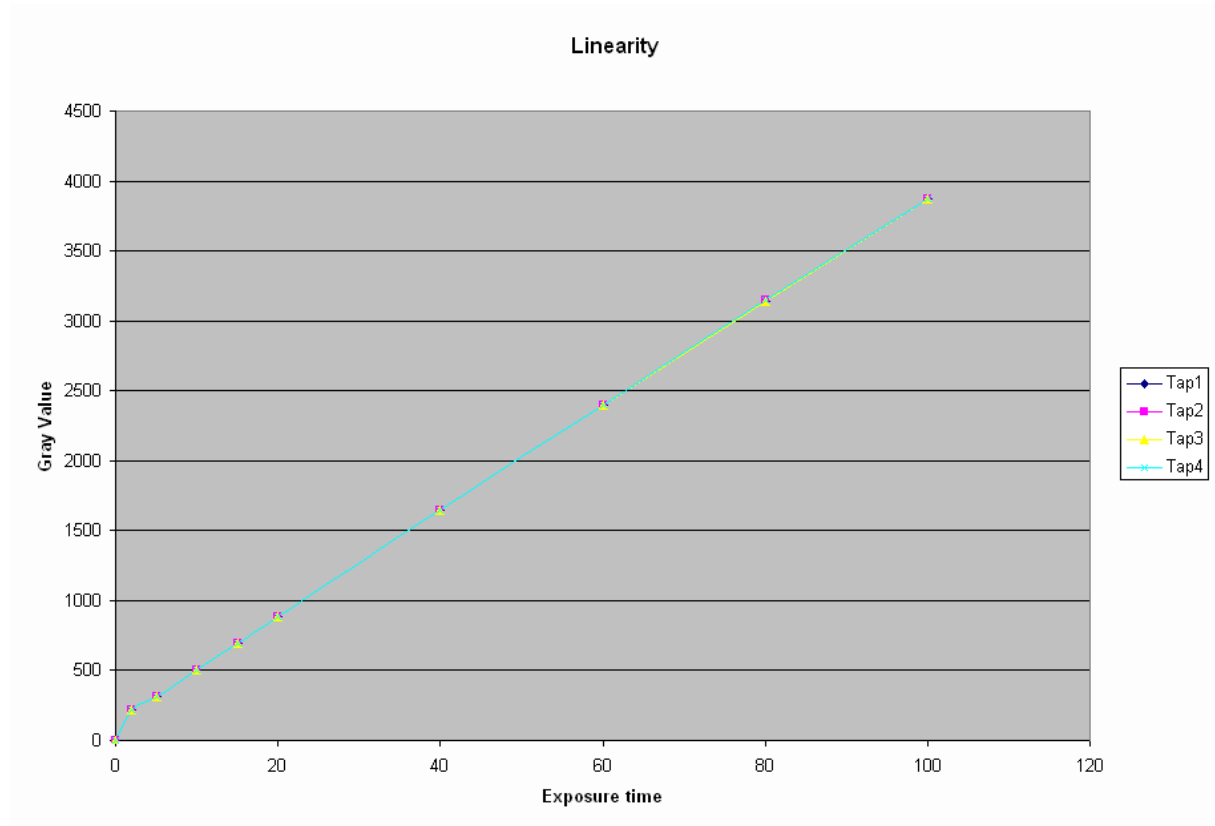
## Sensitivity of camera



**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".

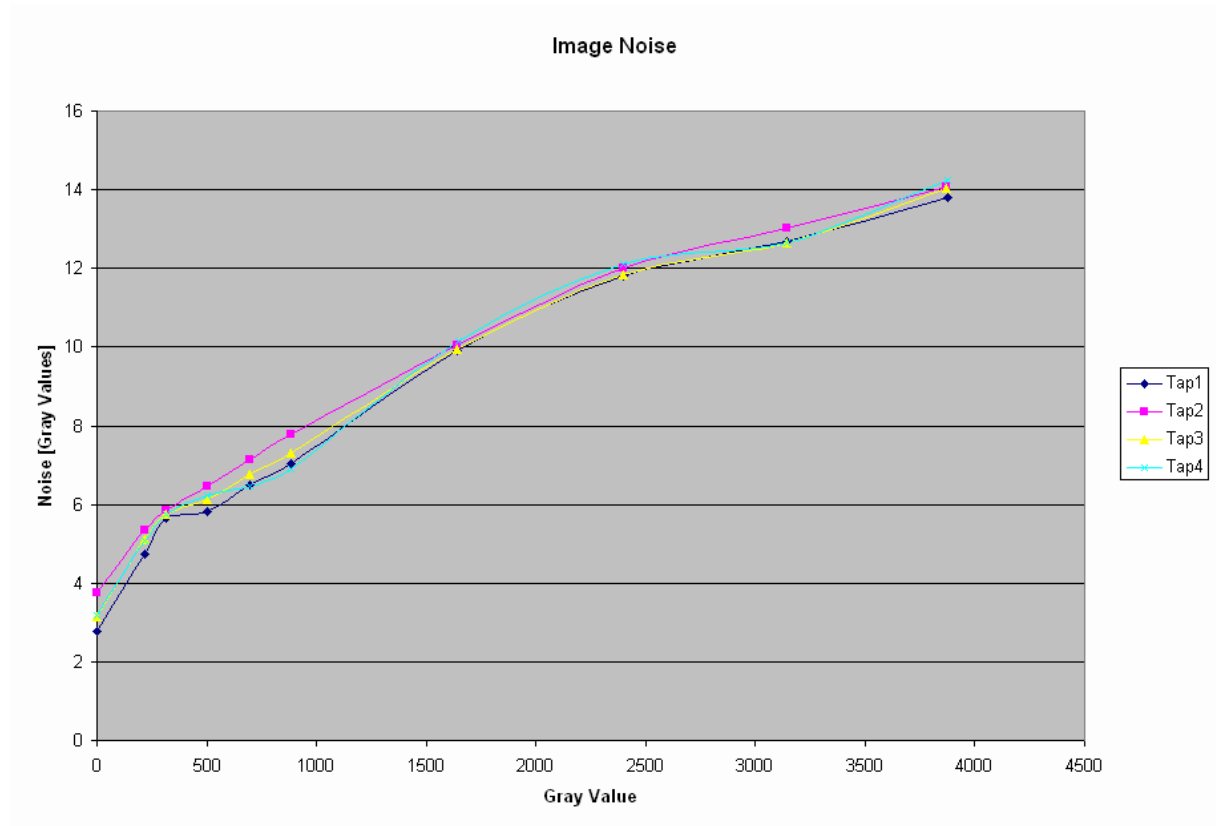
## Sensor Linearity



**Remark:**

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

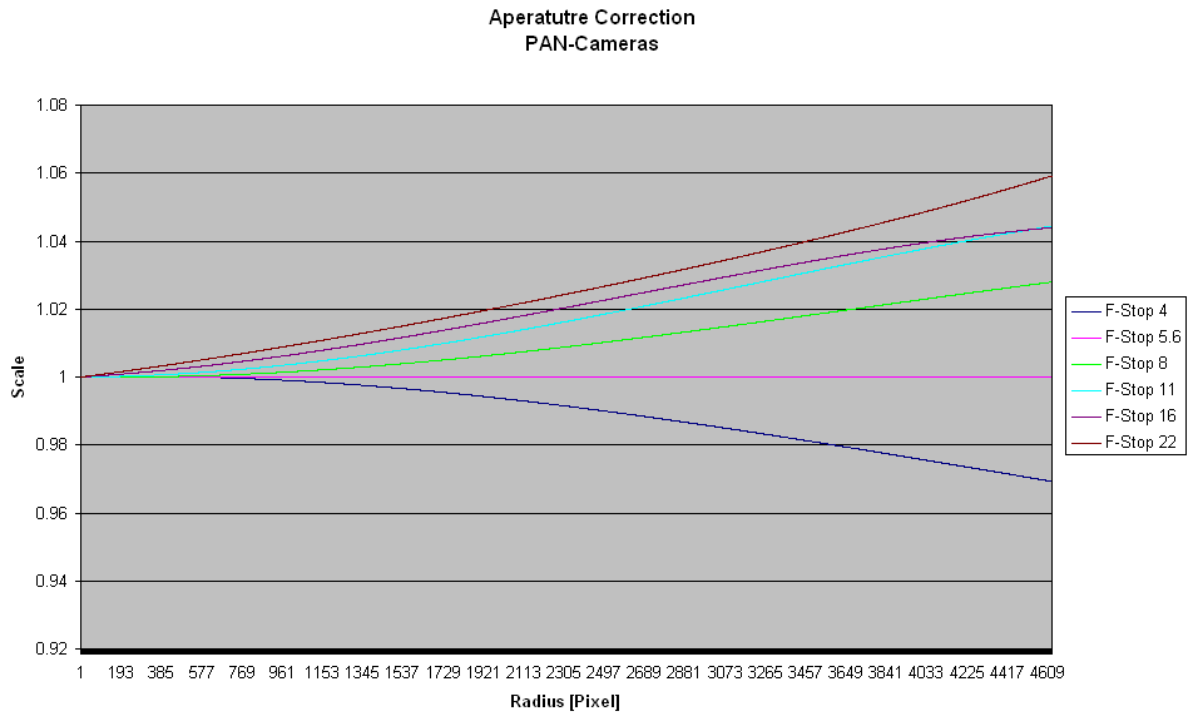
## Sensor Noise



**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: 24

Number of defect clusters: 0

Number of defect columns: 0

Nr	Row	Column
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0	3959	4274
1	3960	4274
2	3961	4274
3	3956	4275
4	3957	4275
5	3958	4275





# Calibration Protocol DMC01-107



6	3959	4275
7	3960	4275
8	3961	4275
9	3957	4276
10	3958	4276
11	3959	4276
12	3960	4276
13	3961	4276
14	3959	4277
15	3960	4277
16	3037	5488
17	3036	5489
18	3037	5489
19	352	6026
20	353	6026
21	353	6027
22	354	6027
23	353	6028

Defect Column      RowStart      ColumnStart      RowEnd      ColumnEnd

## Remark

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



Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115769**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-Panchromatic  
Serial Number            00115769

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70


Date of Calibration                      10.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

  
(H. Sohnle)

Person in Charge

  
(S. Schröder)

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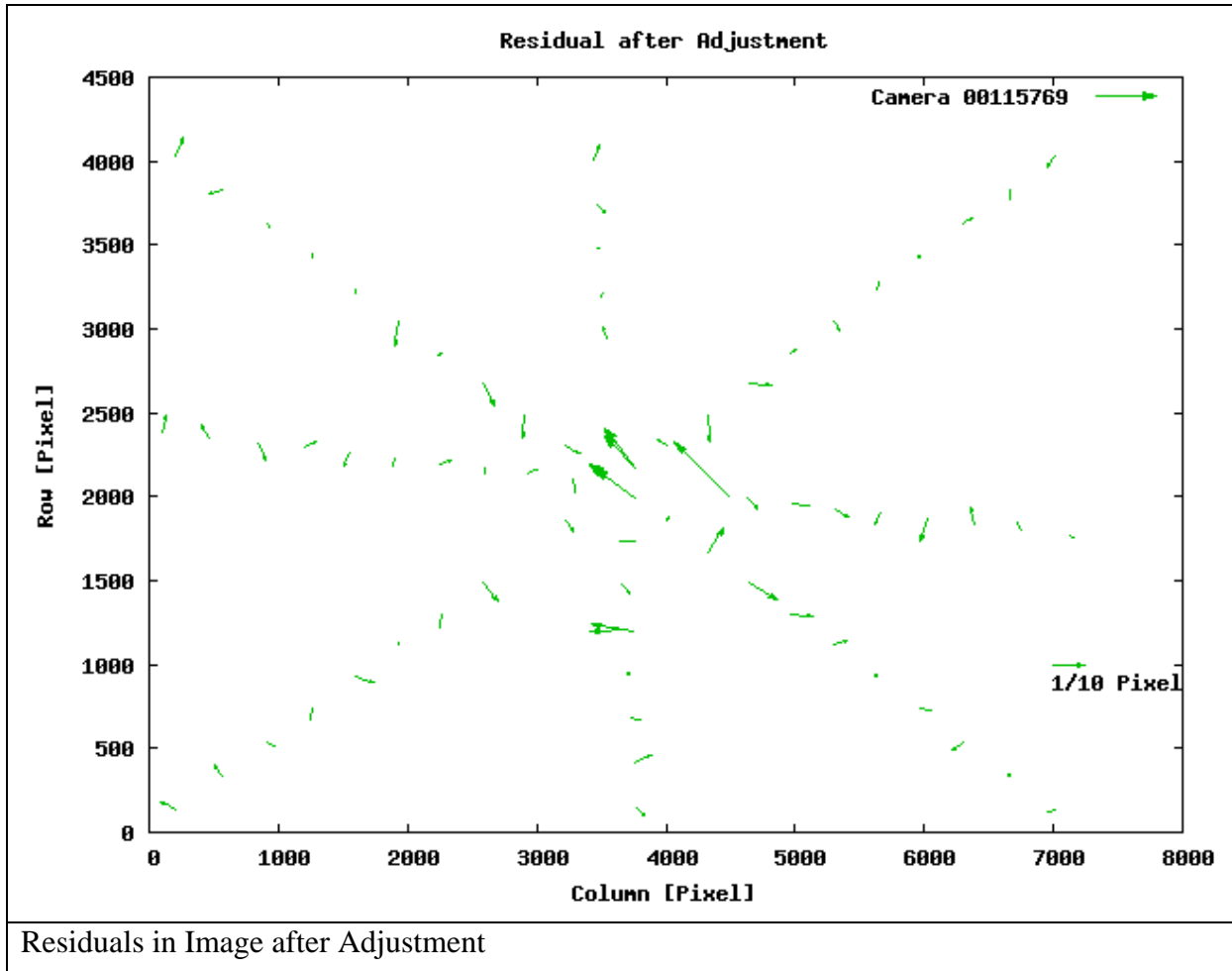
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-Panchromatic
Nominal Focal Length	0.12 m
Serial Number	00115769

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	0.0003921	9.811E-06
	$y_0$	-0.000348	5.977E-06
Focal Length [m]	$\Delta f$	-0.000373	1.777E-06
Radial Distortion	$K_1$	0.5151	0.04602
	$K_2$	-295.3	41.57
	$K_3$	-22490	10960
Decentering distortion	$P_1$	-0.0003364	0.0002236
	$P_2$	0.0001713	0.000114
In Plane Distortion	$B_1$	-1.74E-05	1.196E-05
	$B_2$	2.346E-05	6.929E-06

Adjusted Focal length = 0.12+ dc =0.119627 [m]



Max Residual [ $\mu\text{m}$ ]: 2.6

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".

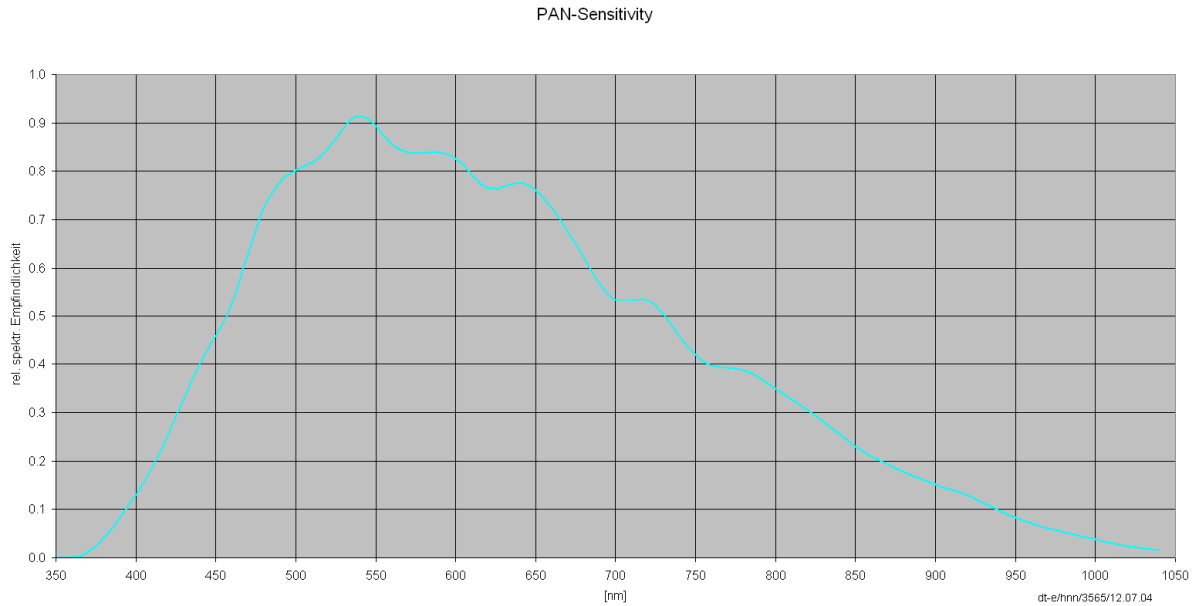
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115769
Sensor Revision Number	2
Lens Revision Number	1
Filter Revision Number	-
Aperture Revision Number	1

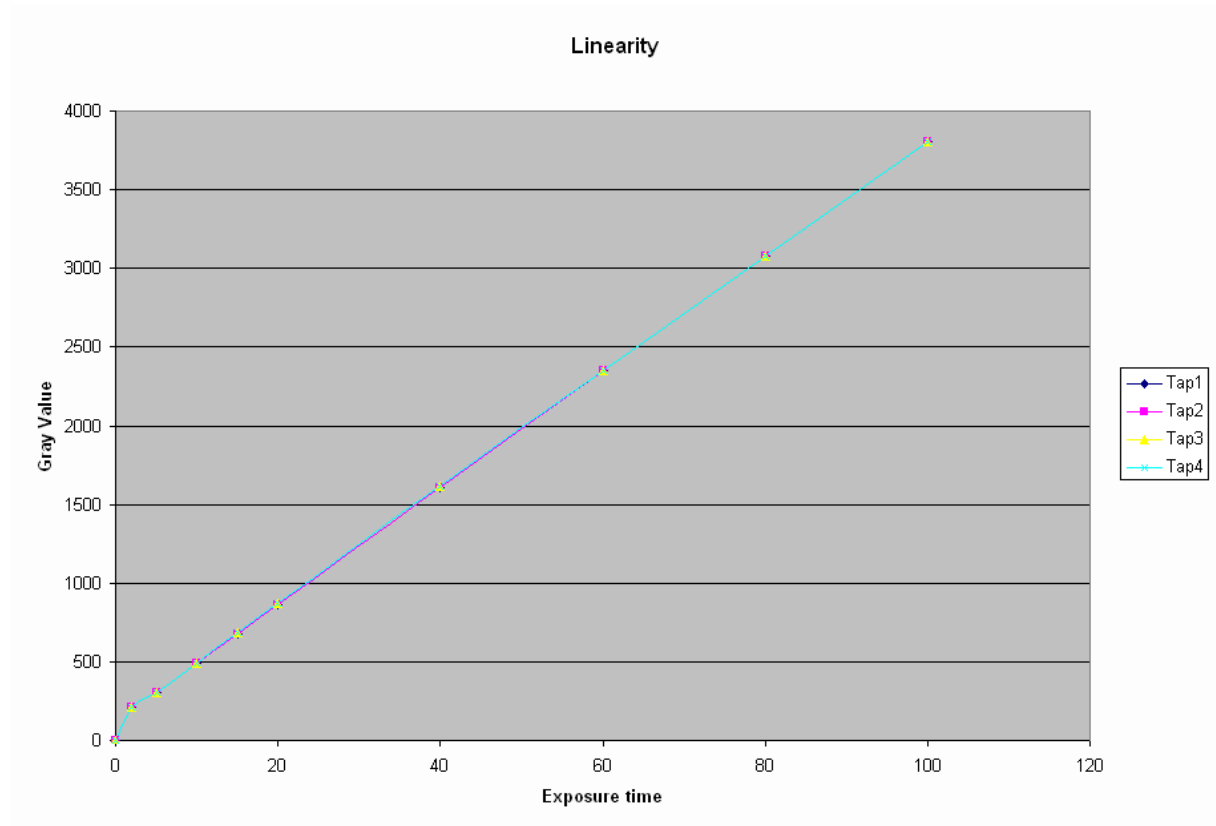
## Sensitivity of camera



**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".

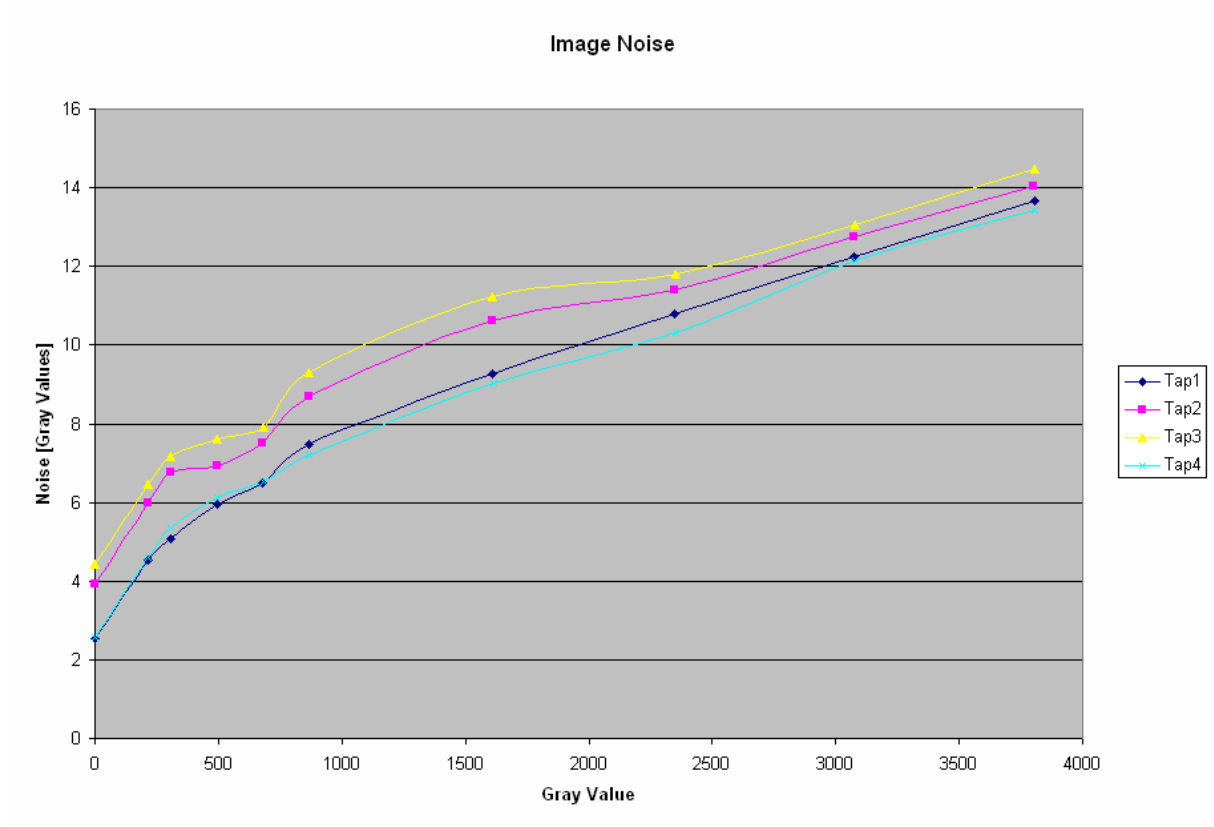
### Sensor Linearity



**Remark:**

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

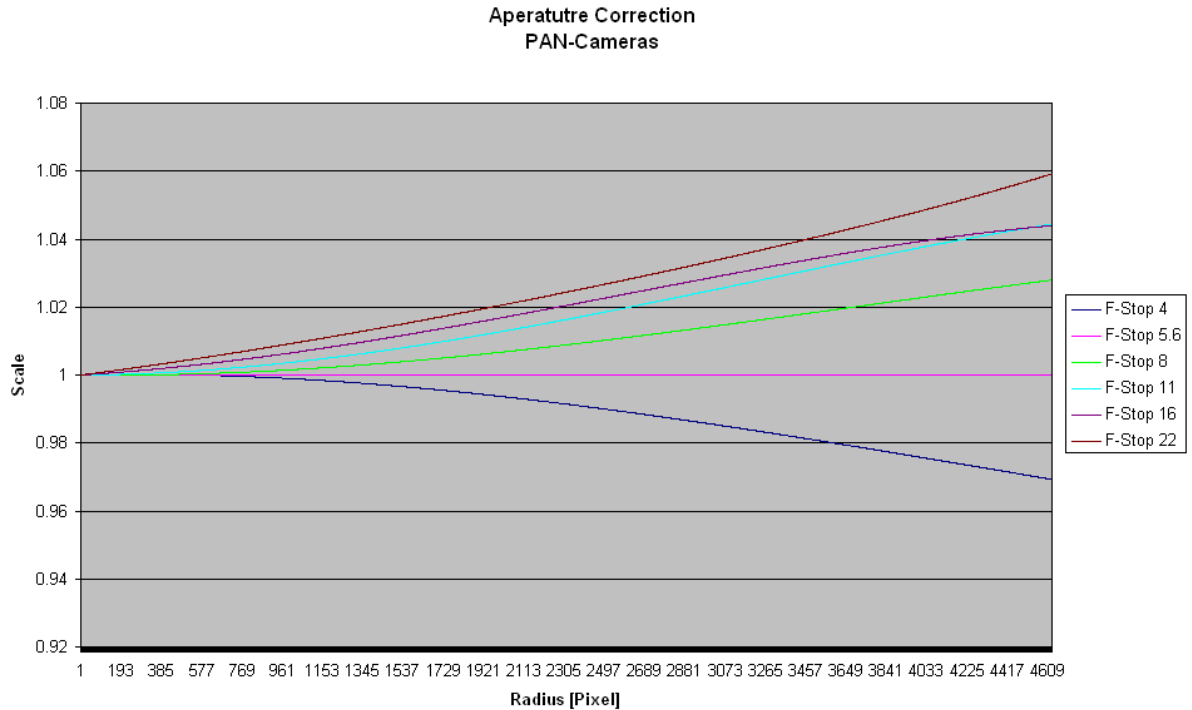
### Sensor Noise



**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: 1

Nr Row Column

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
0	1323	3897	2047	3897

**Remark**

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





Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115846**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-NIR  
Serial Number             00115846

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      01.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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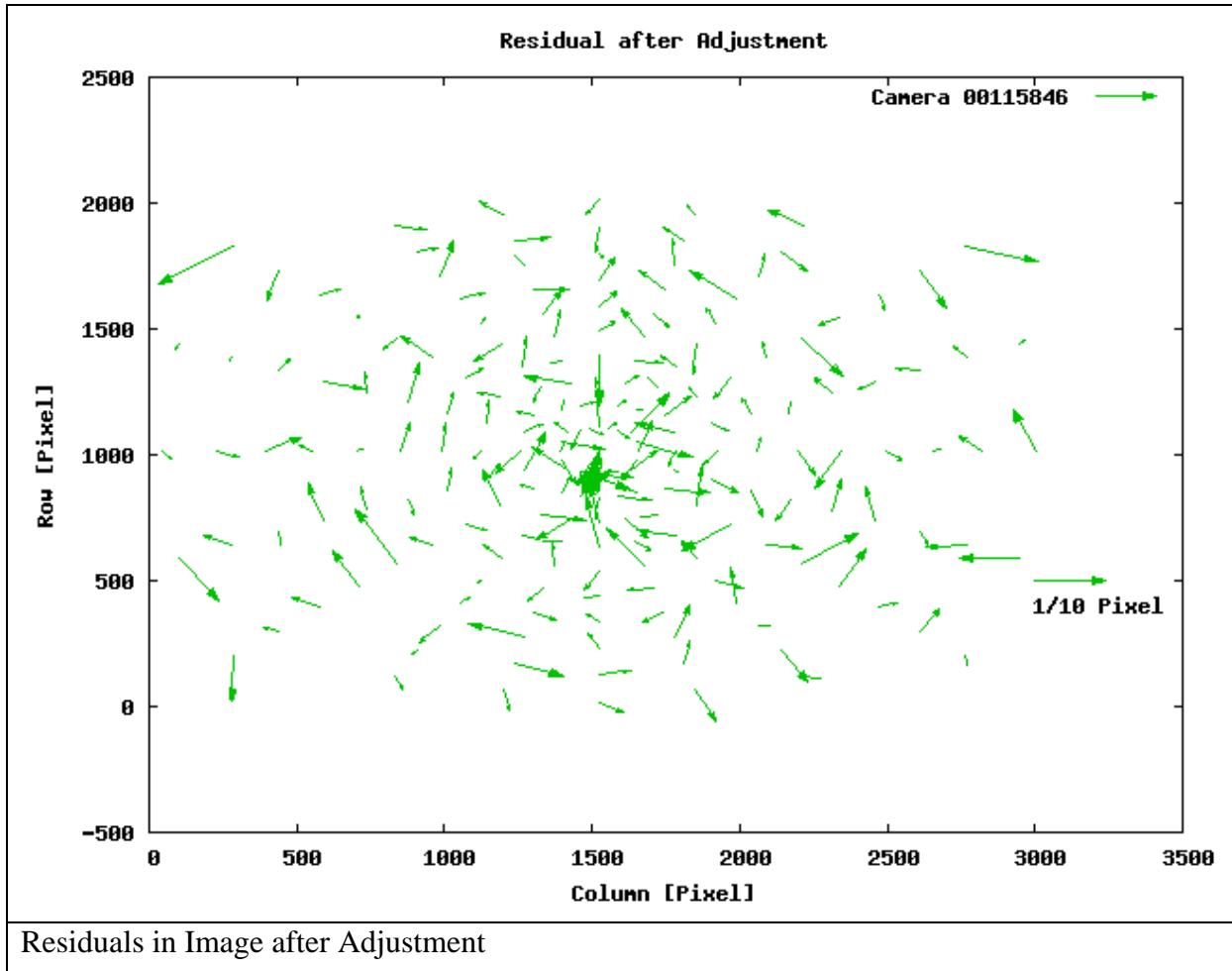
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-NIR
Nominal Focal Length	0.025 m
Serial Number	00115846

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001453	1.238E-06
	$y_0$	0.0001086	8.728E-07
Focal Length [m]	$\Delta f$	-2.876E-05	4.569E-07
Radial Distortion	$K_1$	-143.2	0.3843
	$K_2$	221700	2452
	$K_3$	-146100000	4415000
Decentering distortion	$P_1$	-0.001823	0.0006437
	$P_2$	-0.0005992	0.0003986
In Plane Distortion	$B_1$	6.995E-05	1.13E-05
	$B_2$	8.553E-05	9.136E-06

Adjusted Focal length = 0.025+ dc =0.02497124 [m]



Max Residual [ $\mu\text{m}$ ]: 1.5

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".

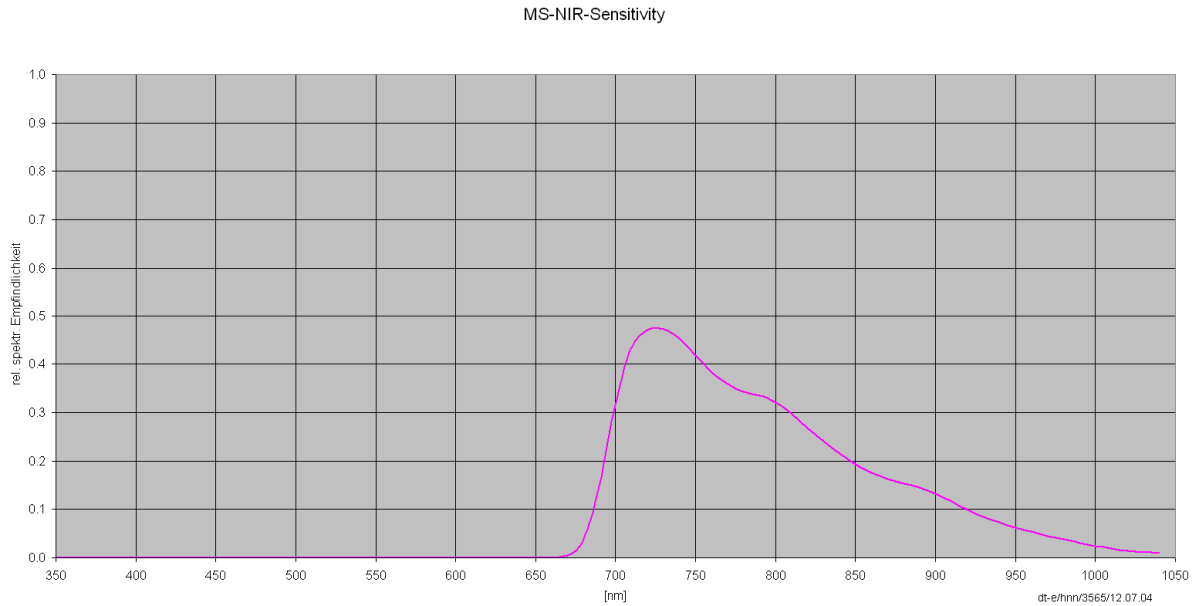
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115846
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

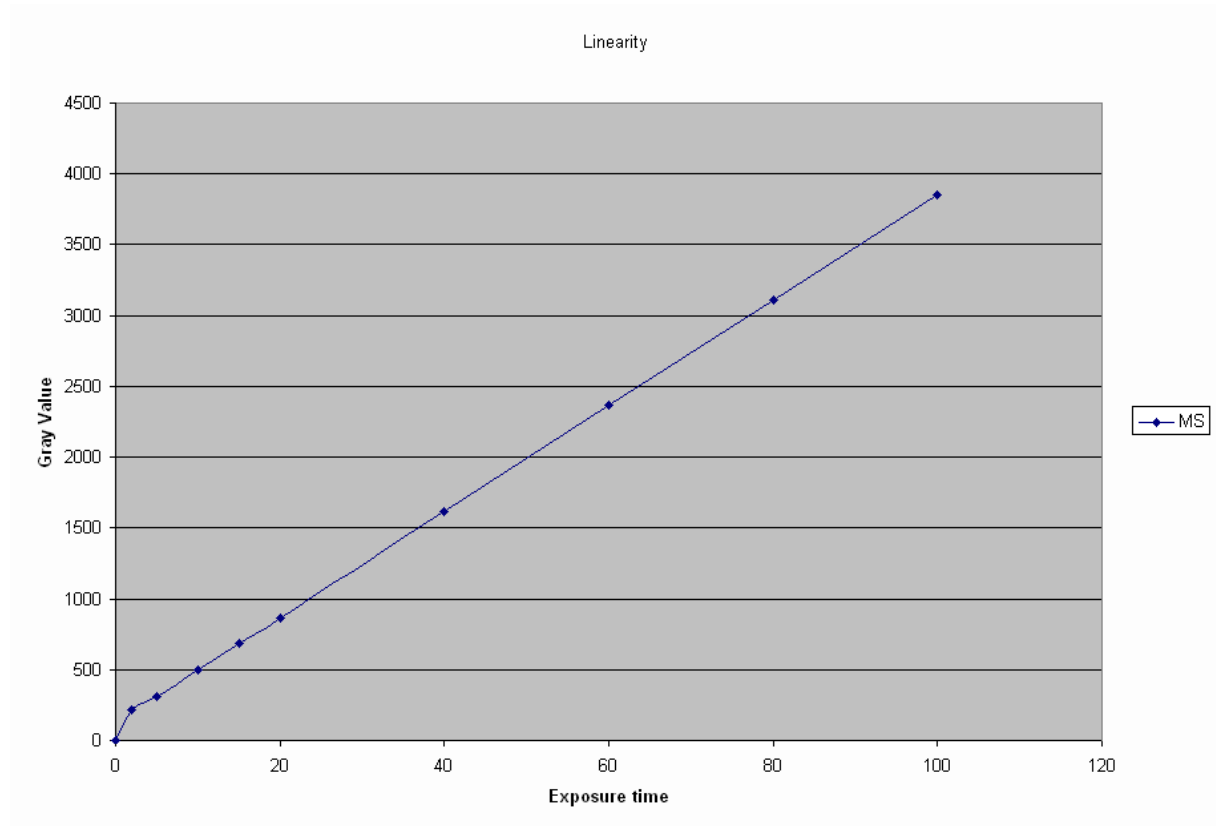
## Sensitivity of camera



**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".

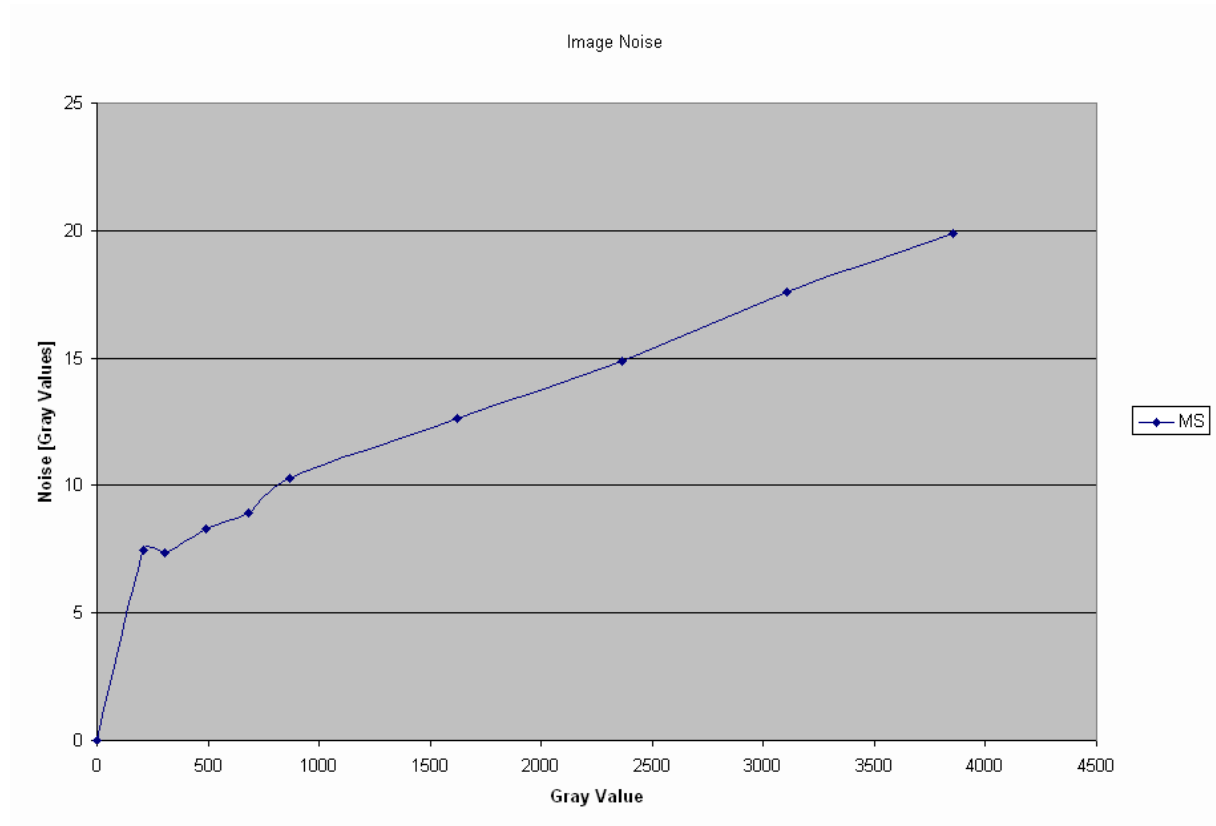
### Sensor Linearity



**Remark:**

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

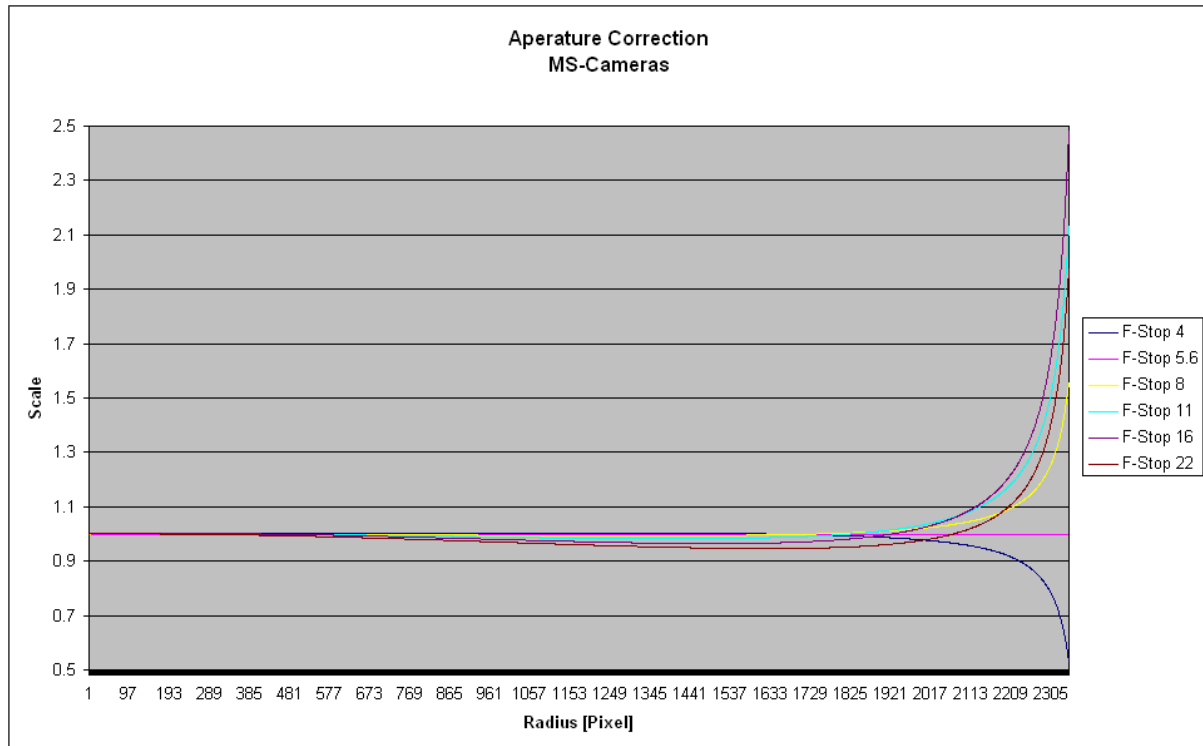
### Sensor Noise



**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  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115856**

Object                    Digital Aerial Survey Camera  
Manufacturer            Z/I Imaging D-73431 Aalen  
Type                      DMC-MS-Blue  
Serial Number            00115856

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      02.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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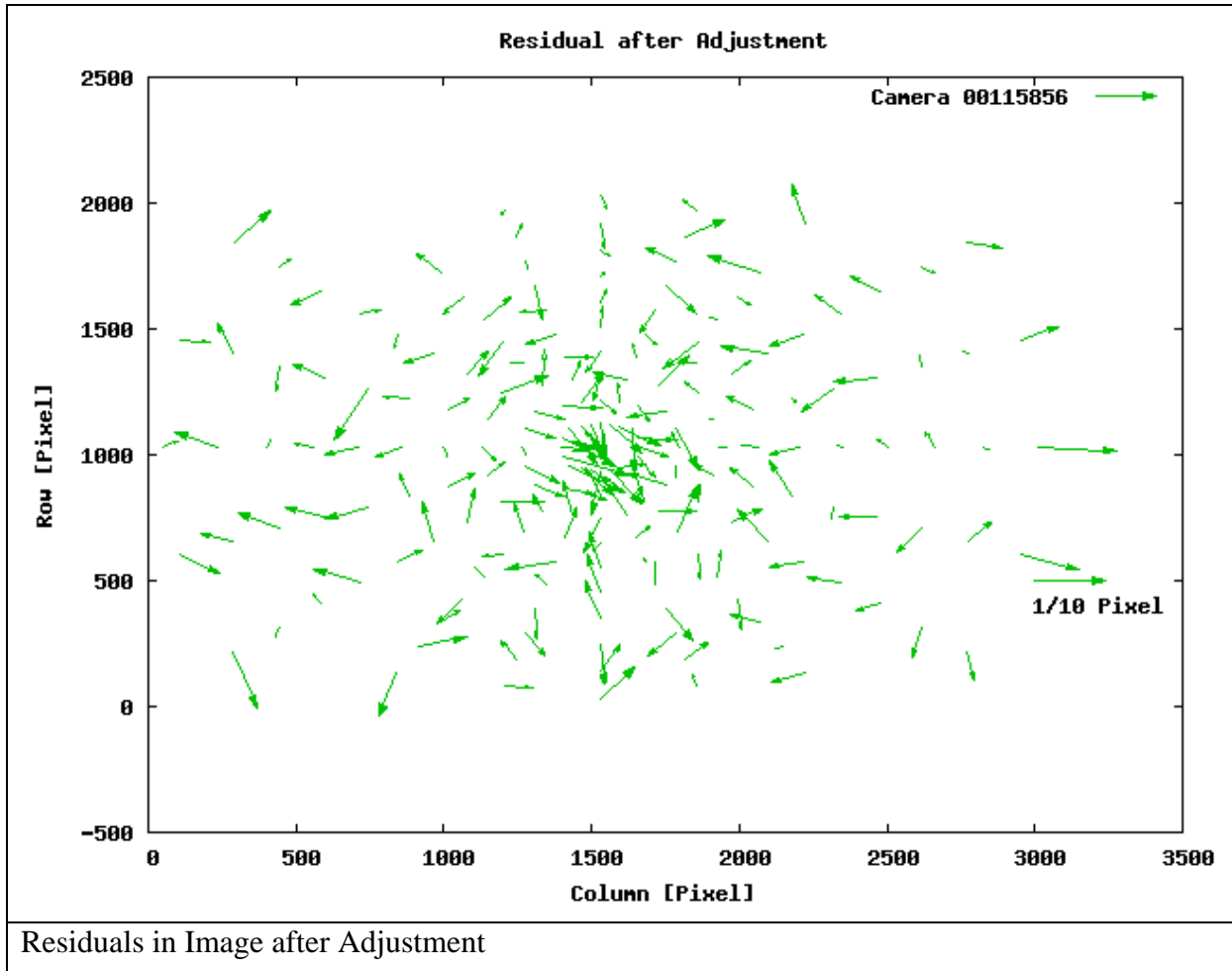
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Blue
Nominal Focal Length	0.025 m
Serial Number	00115856

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-5.295E-05	1.273E-06
	$y_0$	-7.458E-05	8.796E-07
Focal Length [m]	$\Delta f$	-4.423E-05	4.551E-07
Radial Distortion	$K_1$	-139.1	0.3838
	$K_2$	221900	2447
	$K_3$	-153400000	4406000
Decentering distortion	$P_1$	-0.0002738	0.0006627
	$P_2$	0.00142	0.0003994
In Plane Distortion	$B_1$	0.0001559	1.137E-05
	$B_2$	-1.549E-05	9.379E-06

Adjusted Focal length = 0.025+ dc =0.02495577 [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”.

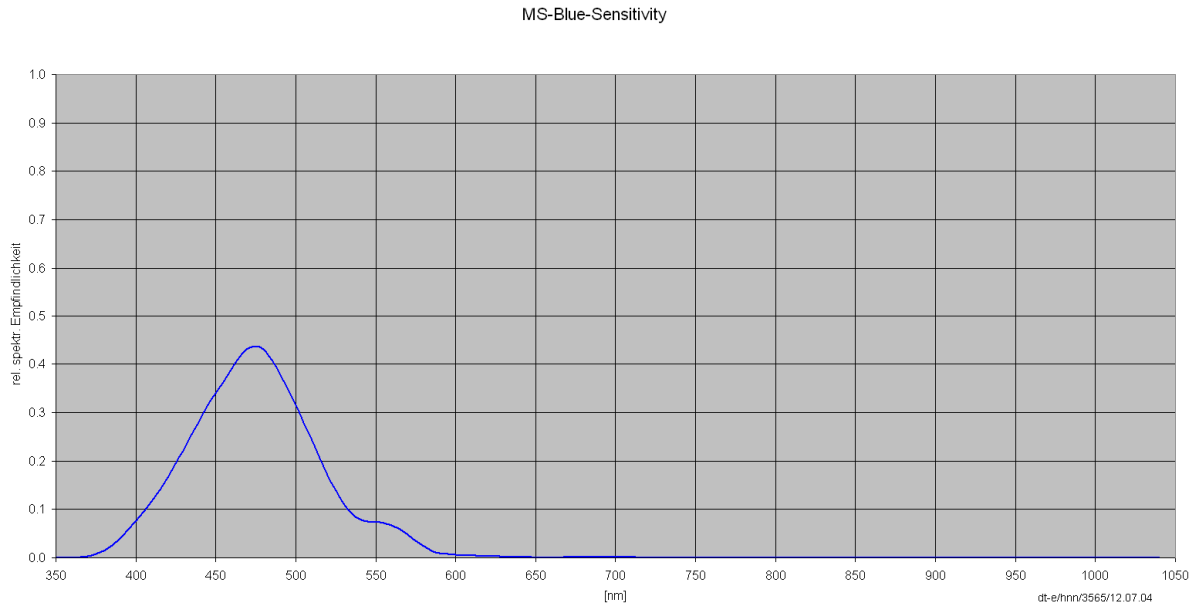
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115856
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

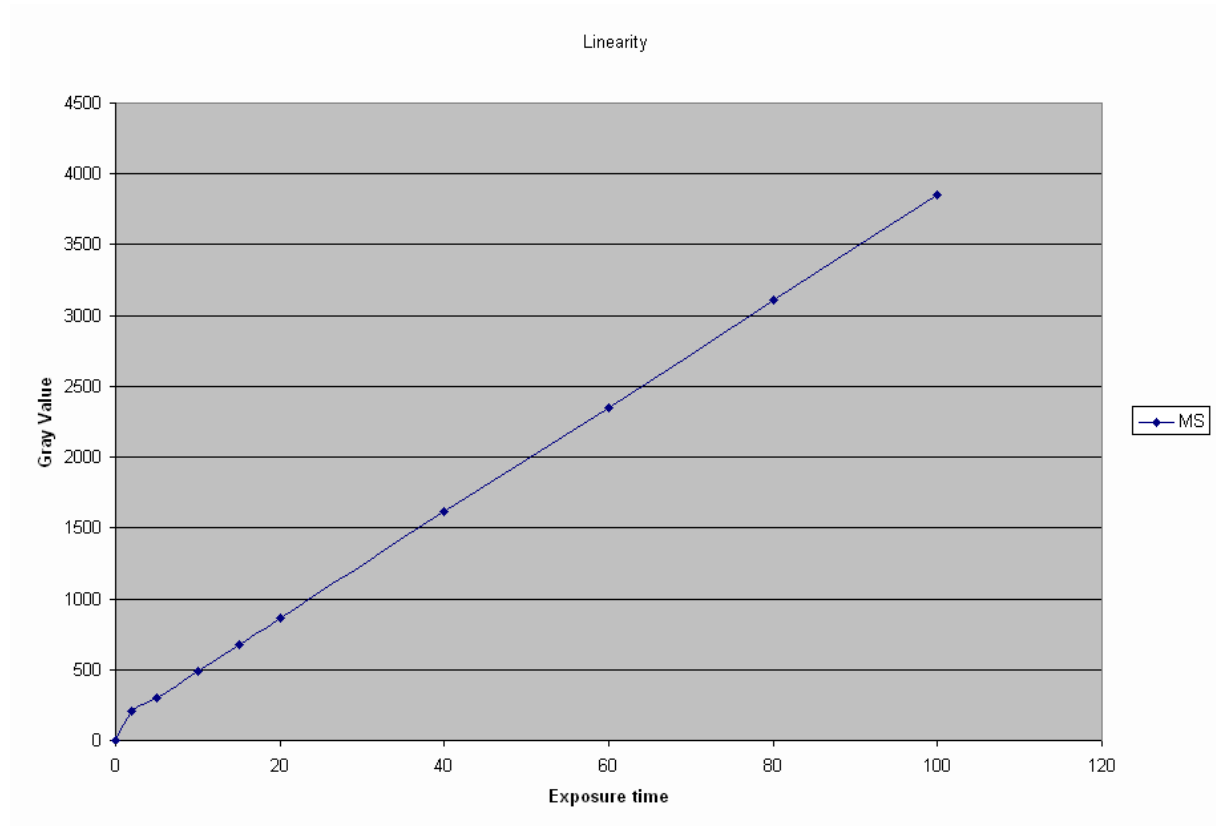
## Sensitivity of camera



**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".

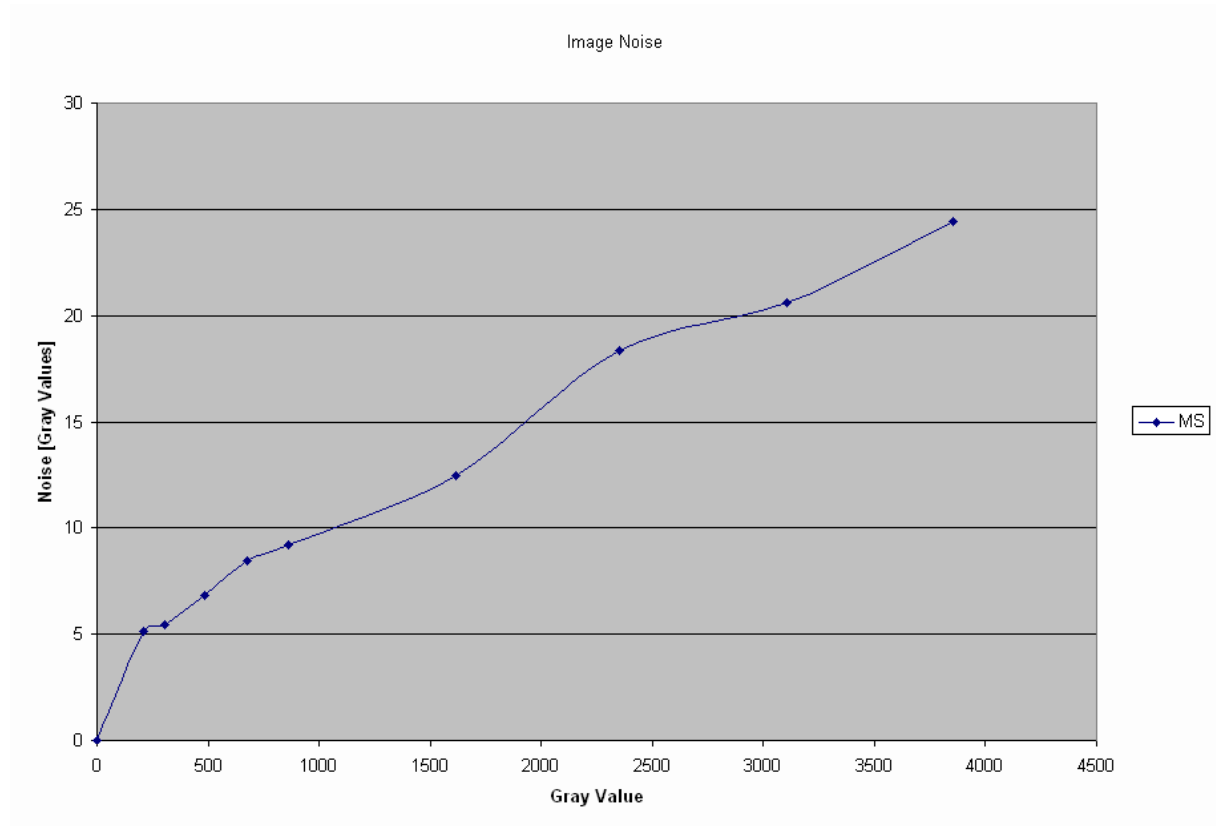
### Sensor Linearity



**Remark:**

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

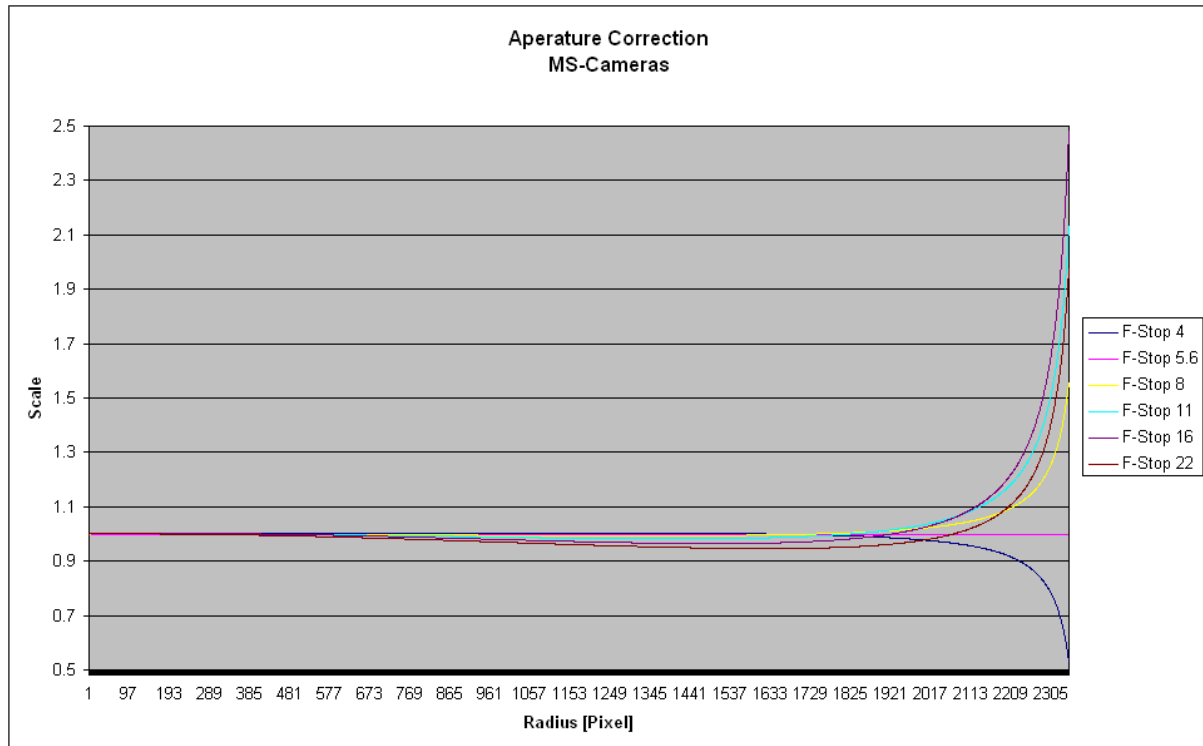
### Sensor Noise



**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: 3  
 Number of defect clusters: 0  
 Number of defect columns: 0

Nr	Row	Column
0	1191	223
1	1191	224
2	1192	224

Defect Column	RowStart	ColumnStart	RowEnd	ColumnEnd
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# Calibration Protocol DMC01-107



## Remark

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



Calibration Protocol  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115849**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-Red  
Serial Number              00115849

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      01.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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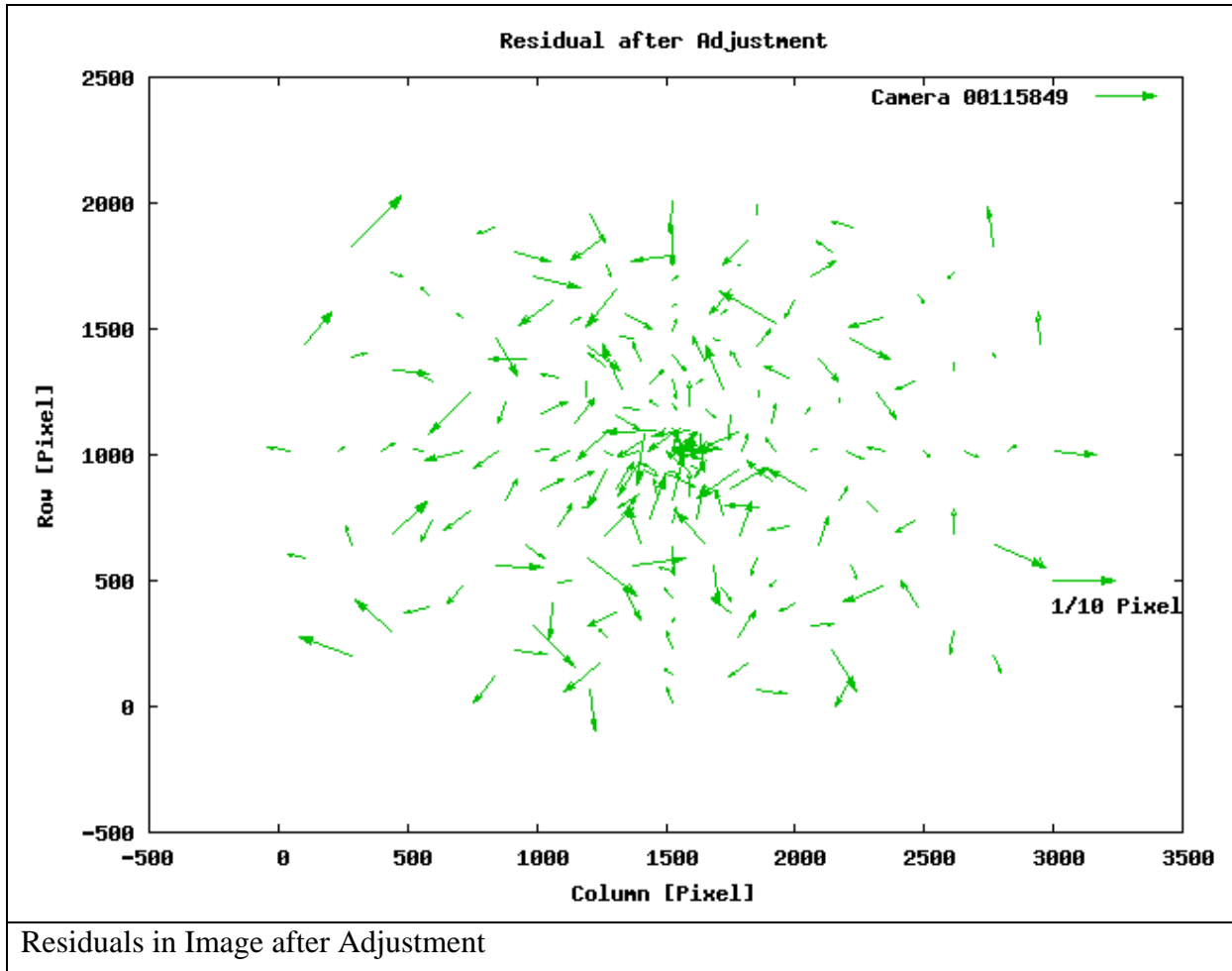
## Geometric Calibration Protocol

### Calibration Parameters for single camera head

Camera Type	DMC-MS-Red
Nominal Focal Length	0.025 m
Serial Number	00115849

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-0.0001071	1.226E-06
	$y_0$	0.0001201	8.644E-07
Focal Length [m]	$\Delta f$	-4.799E-05	4.525E-07
Radial Distortion	$K_1$	-140.4	0.3805
	$K_2$	220300	2428
	$K_3$	-146200000	4371000
Decentering distortion	$P_1$	-0.0001709	0.0006375
	$P_2$	-0.003422	0.0003948
In Plane Distortion	$B_1$	0.0001852	1.119E-05
	$B_2$	-4.069E-05	9.047E-06

Adjusted Focal length = 0.025+ dc =0.02495201 [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”.

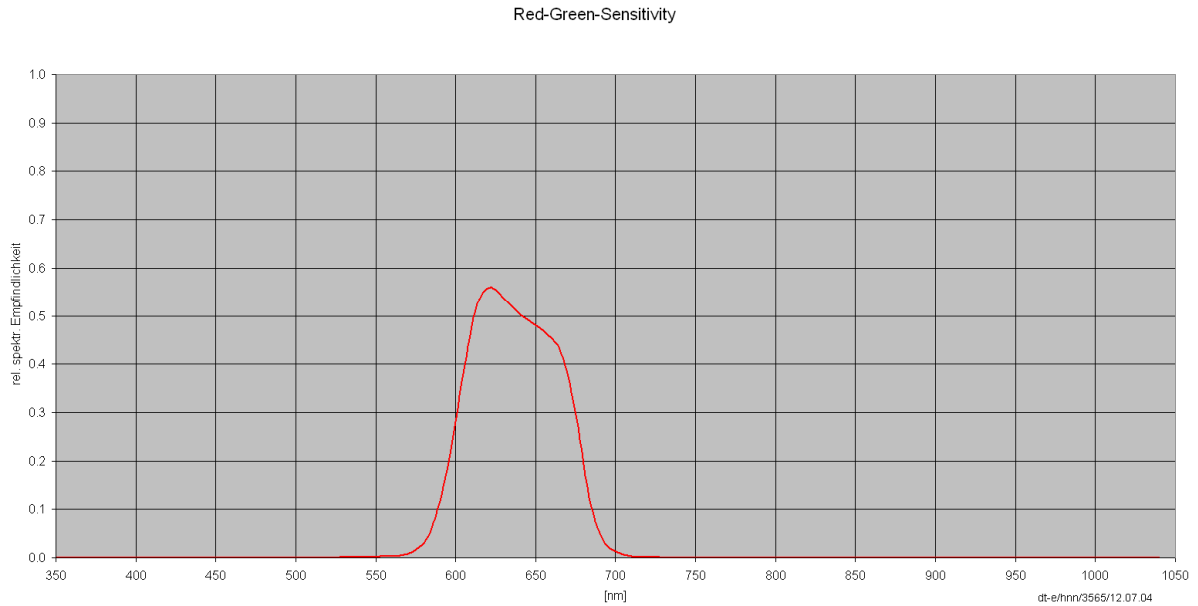
The calibration model is explained in the section “Calibration Model” at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115849
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

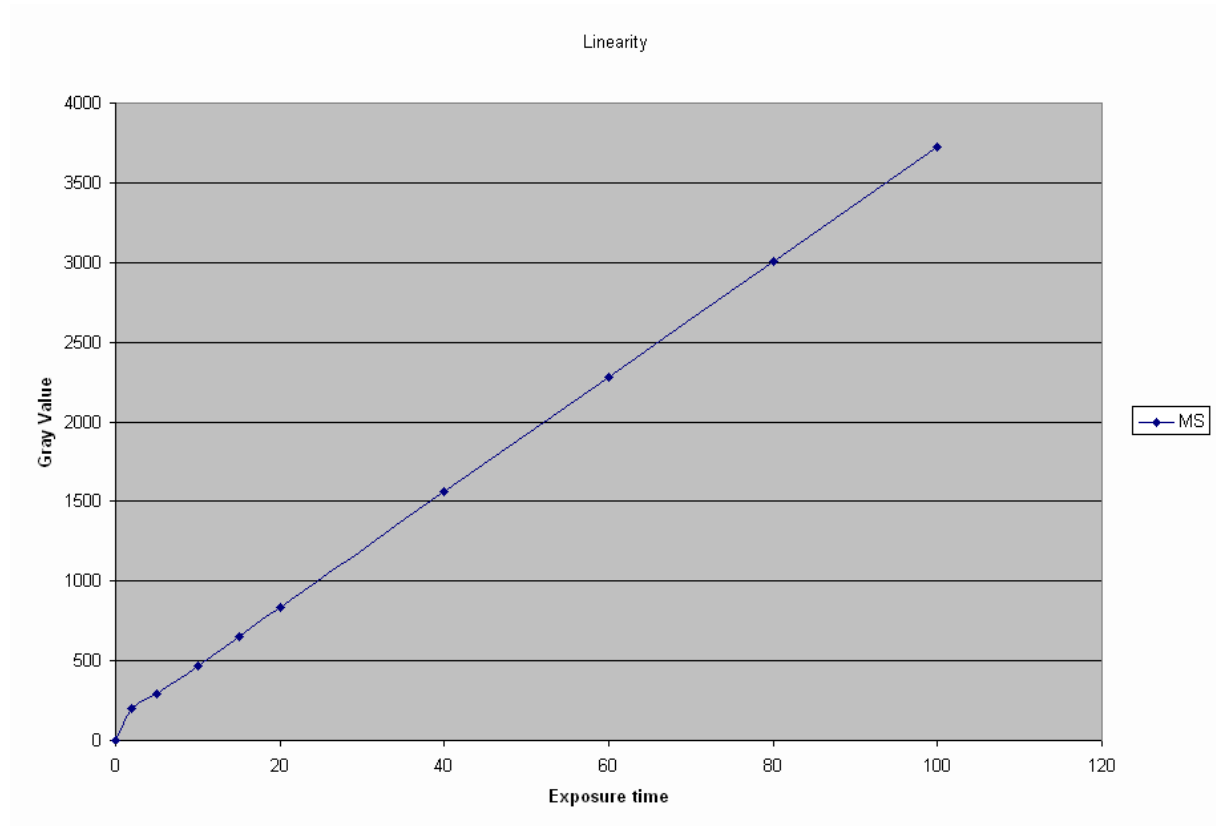
## Sensitivity of camera



**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".

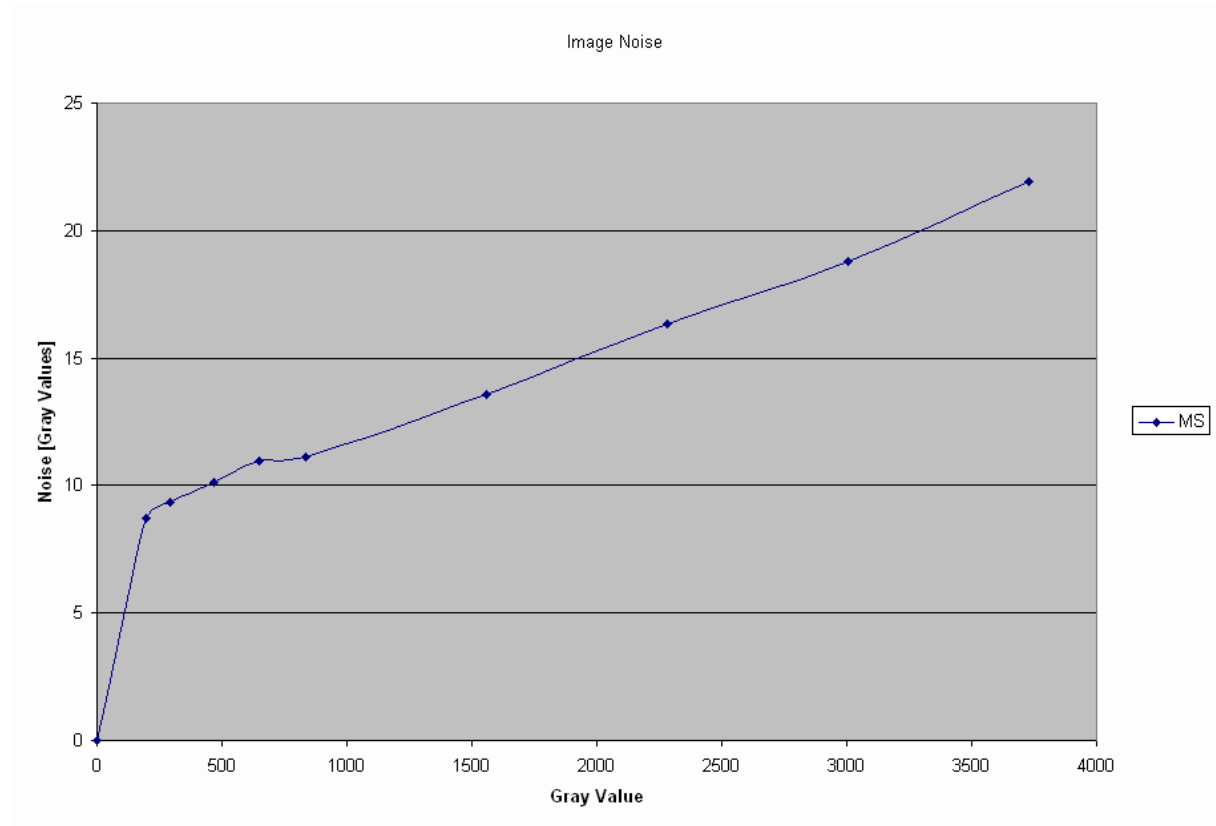
### Sensor Linearity



**Remark:**

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

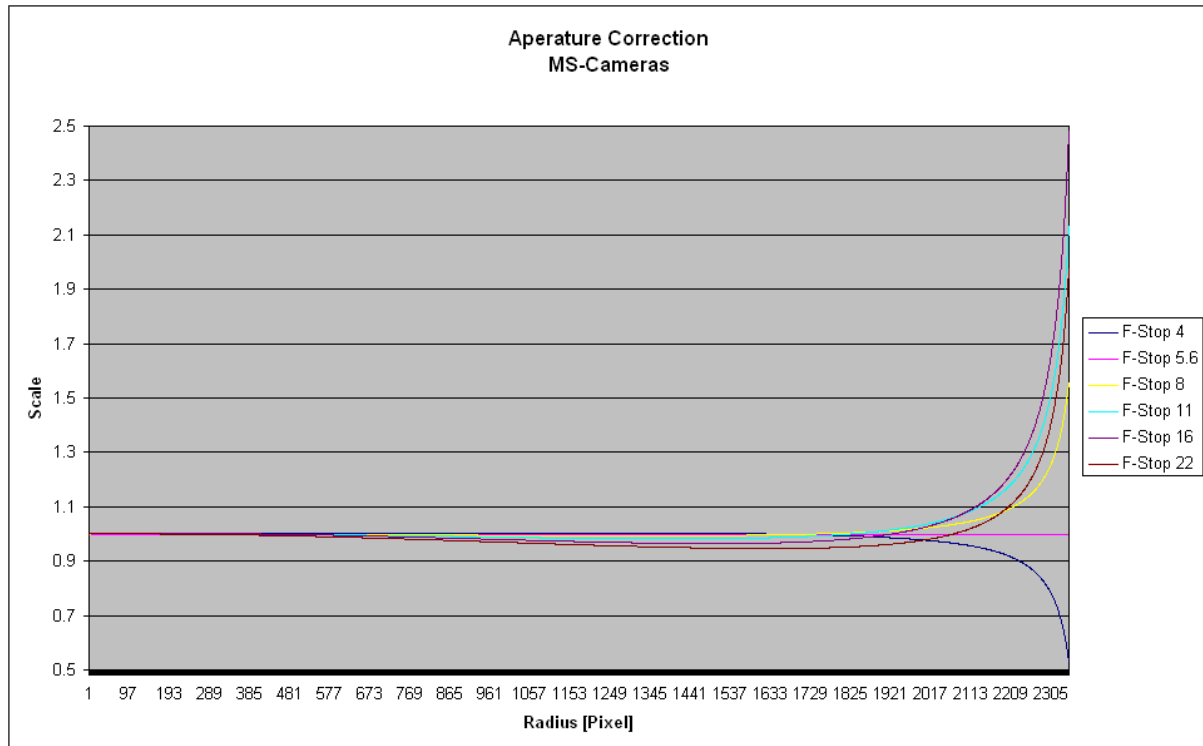
### Sensor Noise



**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  
DMC01-107



**Calibration Certificate**

**N<sup>o</sup> 00115844**

Object                      Digital Aerial Survey Camera  
Manufacturer              Z/I Imaging D-73431 Aalen  
Type                         DMC-MS-Green  
Serial Number              00115844

Calibration performed at:  
Carl Zeiss Jena

Number of pages of the certificate    70

Date of Calibration                      11.Oct.2007

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CertifiedDate

05.Nov.2007

Division Head

(H. Sohnle)

Person in Charge

(S. Schröder)

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## Geometric Calibration Protocol

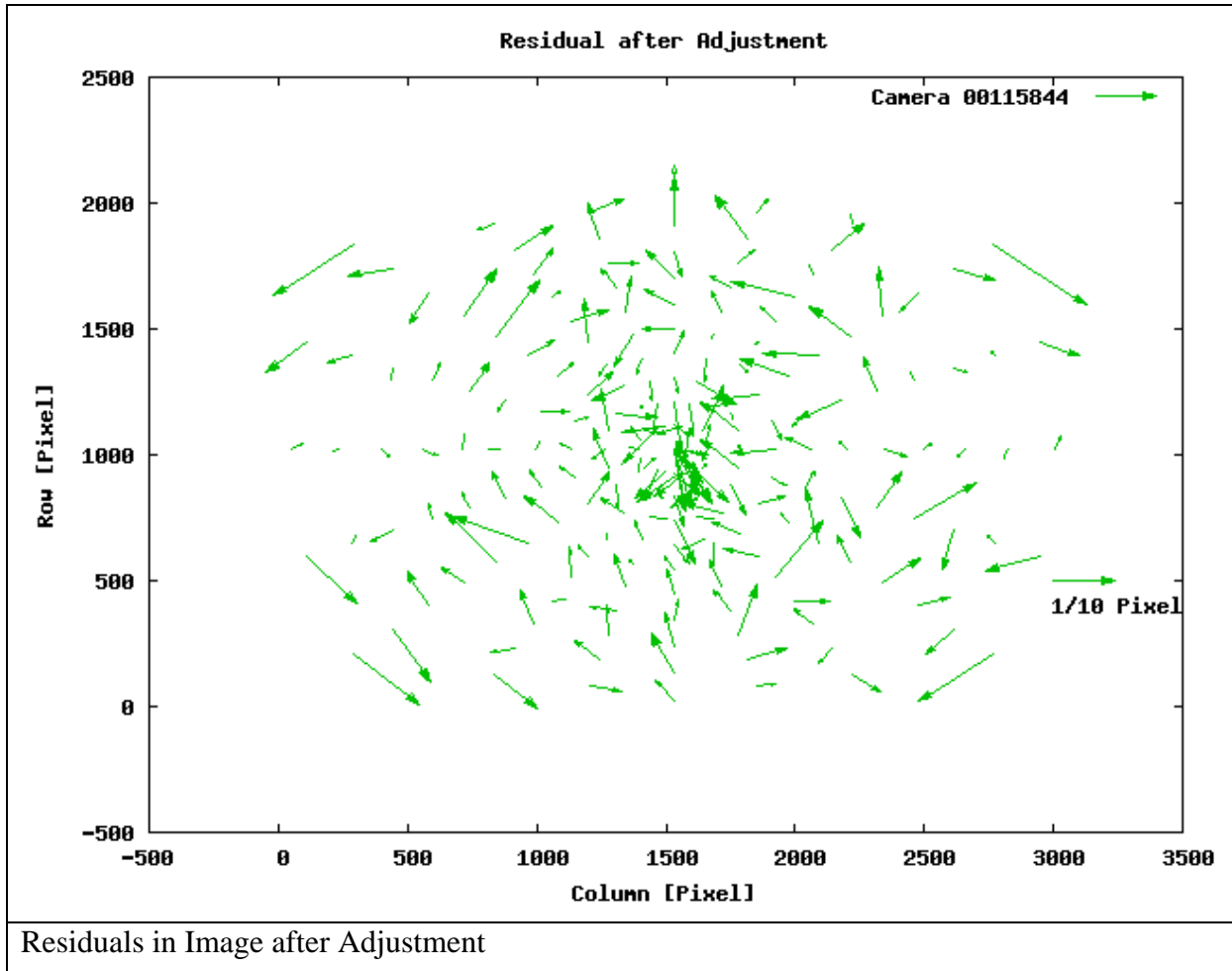
### Calibration Parameters for single camera head

Camera Type	DMC-MS-Green
Nominal Focal Length	0.025 m
Serial Number	00115844

	Param	Adjusted	Std.dev.
Principal Point [m]	$x_0$	-6.927E-05	1.563E-06
	$y_0$	2.321E-05	1.102E-06
Focal Length [m]	$\Delta f$	-6.684E-05	5.767E-07
Radial Distortion	$K_1$	-135.8	0.485
	$K_2$	207000	3094
	$K_3$	-129100000	5571000
Decentering distortion	$P_1$	0.0008097	0.0008126
	$P_2$	-0.003042	0.0005032
In Plane Distortion	$B_1$	6.769E-05	1.427E-05
	$B_2$	-4.714E-05	1.153E-05

Adjusted Focal length = 0.025+ dc =0.02493316 [m]





Max Residual [ $\mu\text{m}$ ]: 2.2

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".

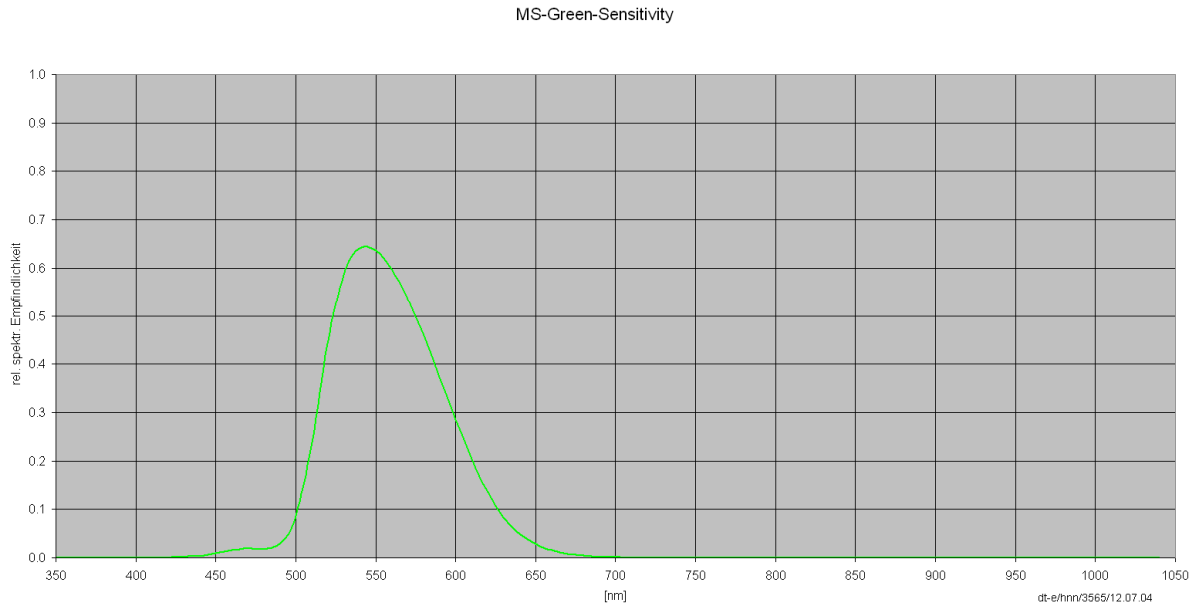
The calibration model is explained in the section "Calibration Model" at the end of this documentation.

## Radiometric Calibration Protocol

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

Camera ID	00115844
Sensor Revision Number	0
Lens Revision Number	1
Filter Revision Number	1
Aperture Revision Number	1

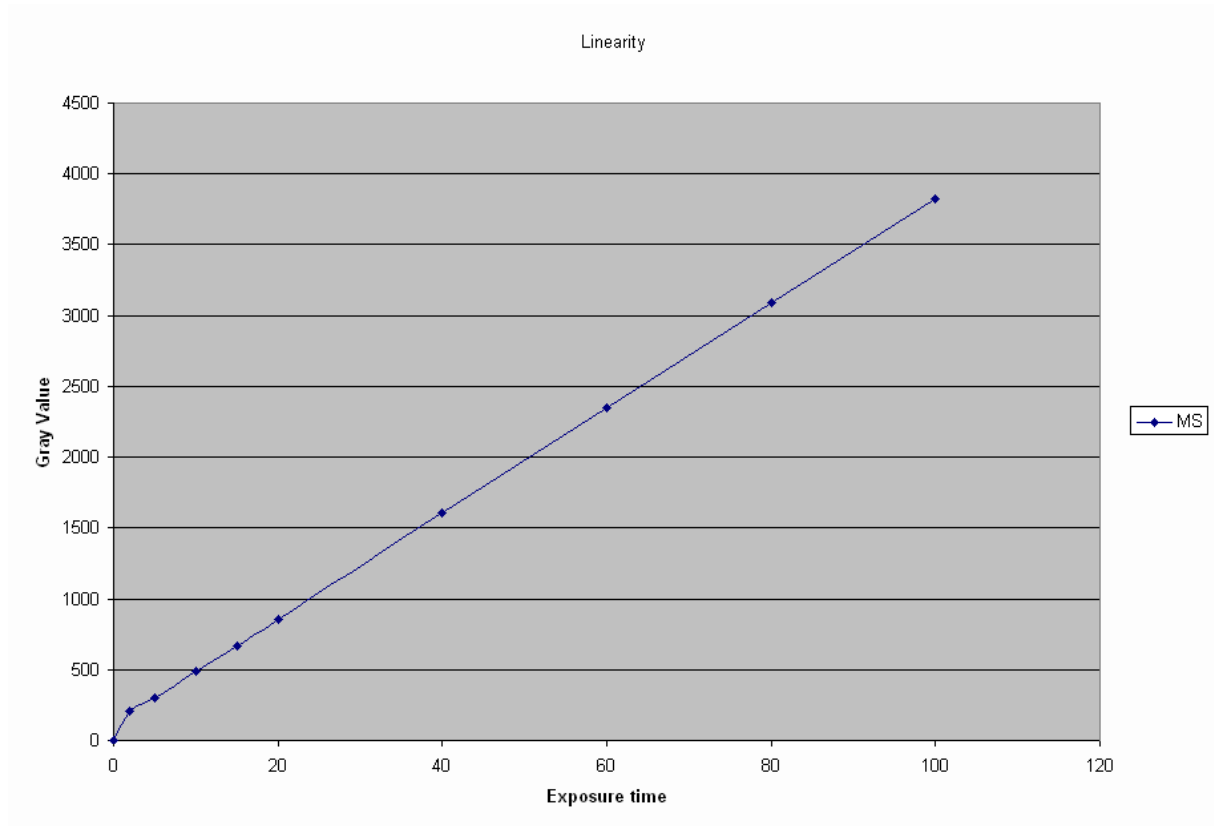
## Sensitivity of camera



**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".

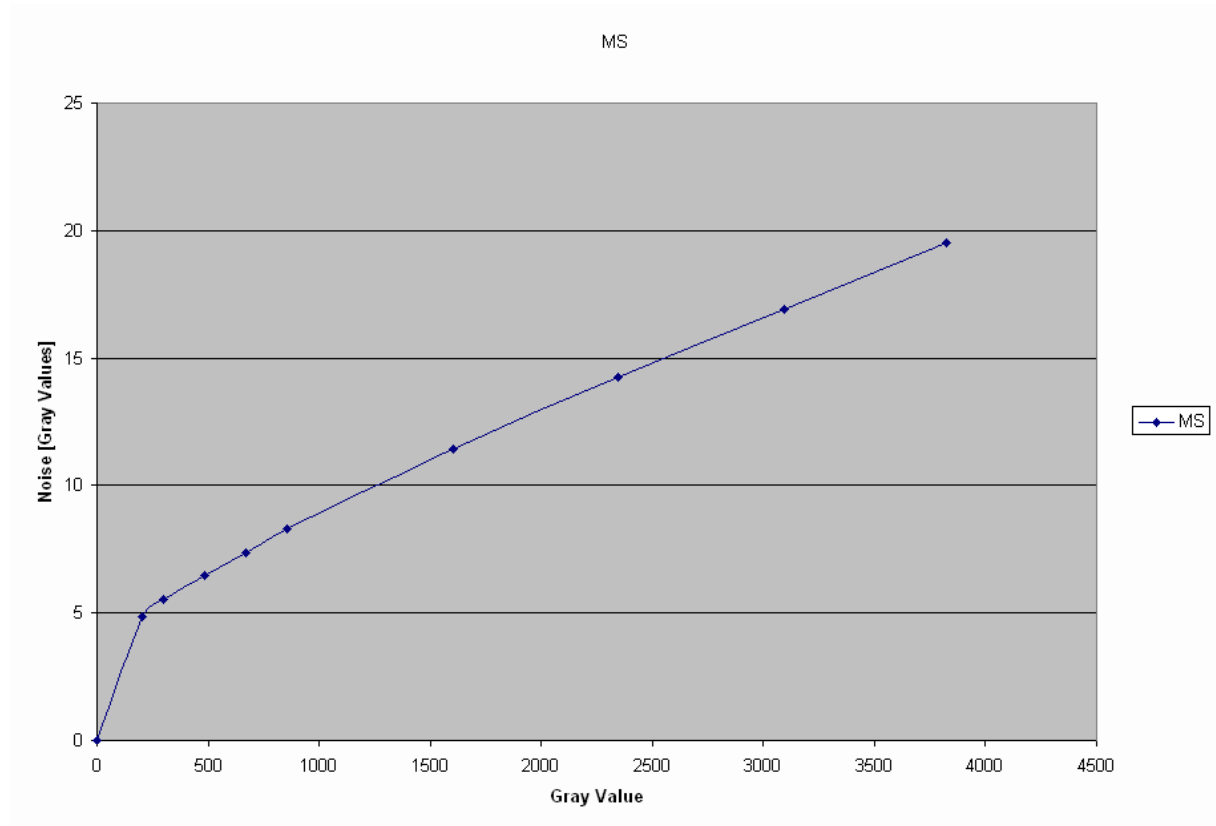
### Sensor Linearity



**Remark:**

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

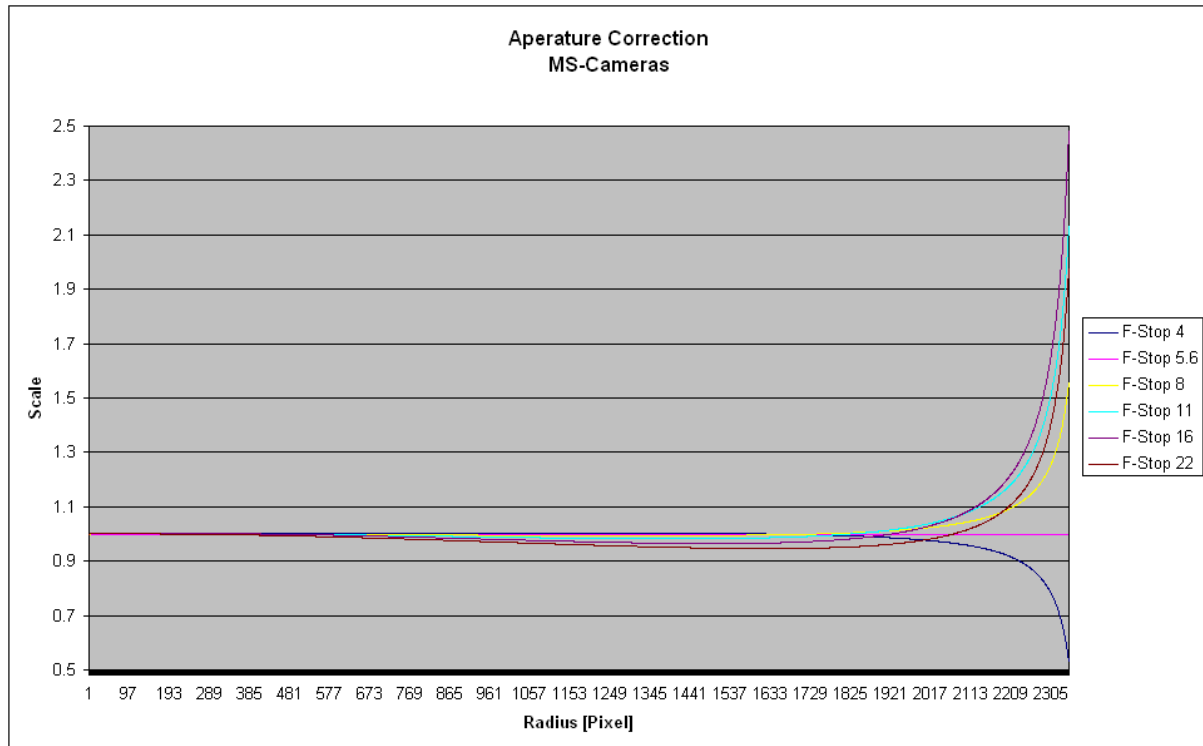
### Sensor Noise



**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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Dörstel C., Jacobsen K., Stallmann D. (2003): DMC – Photogrammetric accuracy – Calibration aspects and Generation of synthetic DMC images, Eds. M. Baltsavias / A.Grün, Optical 3D Sensor Workshop, Zürich

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.